VOL-XIII NO-1

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

JULY 1923

SUMMER MEETING NUMBER

SOCIETY OF AUTOMOTIVE ENGINEERS Inc.
29 WEST 39TH STREET NEW YORK

THE

JOURNAL
OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Published by the Society of Automotive Engineers, Inc., 29 *W. 39th St., New York*

Issued monthly, $1 a number, $10 a year; foreign $12 a year; to members, 50 cents a number, $5 a year. Entered as second-class matter, Aug. 23, 1917, at the post office at New York, N. Y., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized on Aug. 2, 1918.

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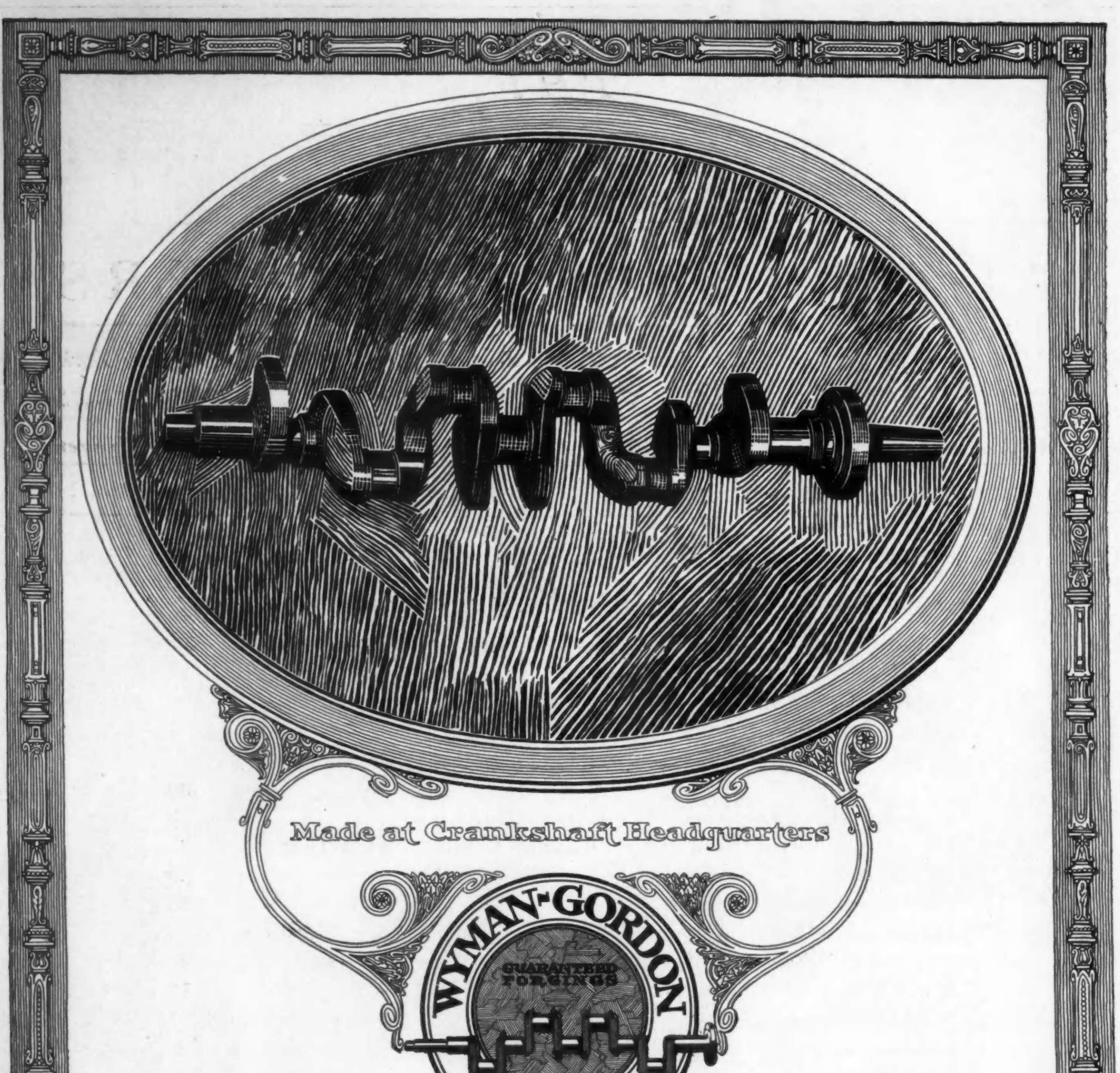
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WYMAN-GORDON
GUARANTEED FORGINGS
STANDARD OF THE INDUSTRY
FOREMOST IN SCIENTIFIC DEVELOPMENT

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XIII July, 1923 No. 1

Eng. Direct

Chronicle and Comment

A Few Important Facts

A National highway-system will reduce the cost of living and promote National security.

The car-owner is his own "engineer," traffic manager and also president of his transportation line.

About 90 per cent of the Country's taxes are paid by owners of automobiles.

Only 9 per cent of all the cars are in cities of 500,000 or over.

Every day in every way our cars grow better and better.

Oil-Films in High-Speed Bearings

IN *Engineering* (London) for March 3, 1922, a very interesting report of tests made at the College of Technology, Manchester, England, to determine the thickness and resistance of oil-films in high-speed bearings is presented. This article, which will be found on p. 101, is reprinted in full because it presents one of the few successful attempts to measure the thickness of oil-films in bearings, and because it verifies certain features of the theory of bearing lubrication not before subjected to direct experiment. While written from the point of view of steam turbine lubrication, the results are equally applicable to the lubrication of shaft bearings in general.

Service and Foreign Membership

IN view of the disproportionately small salaries paid engineers employed by the Government and of the fact that members of the Society residing abroad generally cannot attend meetings of the Society, the Constitution of the Society was amended some years ago to provide for the election of Service Members and Foreign Members. A Service Member is defined as a person 26 years of age or over, engaged exclusively with the United States Government; and a Foreign Member as a resident of countries other than the United States, Canada, Mexico or Cuba. The required qualifications for election to either grade are the same as those for full Member grade. A full Member who has become eligible for either the Service or the Foreign grade may upon written request be transferred to such grade. After the transfer, the lower annual dues of the grades apply, that is $10, this being the amount of the annual dues that Junior members pay. In turn, the Constitution provides that Service and Foreign Members shall give due notification of their termination of connection with the Service or change of residence to territory not designated as foreign.

All full Members of the Society who are eligible for Service or Foreign grade, and wish to be transferred accordingly, should notify the office of the Society in due course, and in any event before Oct. 1 next, the beginning of the 1924 fiscal year.

Government Purchasing Specifications

AT the call of Herbert Hoover, secretary of the Department of Commerce, a meeting was held in the City of Washington last month to consider the matter of broad cooperation in the standardization and improvement of specifications for use by national, state, municipal, county and institutional purchasing departments. Among the organizations represented, in addition to the Society, were the American Engineering Standards Committee, American Society for Testing Materials, the National Association of Purchasing Agents, the Hotel Association, the National Association of Manufacturers, the United States Department of Commerce and the American Electrical Association. It is the intention of the Government to give particular attention in this connection to those commodities in which there is the largest volume of trade, and to coordinate governmental and commercial demands. One feature of the movement is the publication of a book of specifications, standards and simplifications, many of which, of course, already exist. The Department of Commerce bureau will submit the specifications to industry for comment.

It is appreciated that one of the most urgent needs in connection with standardization and specification work is education as to the existence and the merit of formulated recommendations for practice. What Secretary Hoover proposes is to establish a clearing-house on the whole general question of Government specifications, seeking full cooperation from industry and the moral support of commercial associations, as well as the essential service of technical bodies. Revision of Government specifications will be made as promptly as possible when necessary. Obviously, industry should lead largely in new fundamental specification work, and no movement can be forced effectively beyond the point justified by the actual evolutionary results of widespread engineering, scientific and commercial effort. Thoroughgoing work is always

GE 7.

needed in this connection. There is much room for improvement in the working relations of the purchasing and the engineering elements of industry. Government activities of the kind indicated redound to the general benefit in that, if for no other reason, they frequently cause more effective cooperation between industrial bodies.

The Printed Word

THERE is a certain psychological effect that causes the average individual to attach more importance to the printed than to the typewritten word. To be specific, Society members are inclined to feel that tentative recommendations proposed by Divisions or even Subdivisions of the Standards Committee represent the final Society action, merely because such recommendations appear in printed form in THE JOURNAL.

After a recommendation has appeared in THE JOURNAL in a general article on Tentative Standardization Work, it frequently is circularized among engineers by letter with a definite request for comment. Many criticisms that merit consideration may result, often causing revisions of the tentative proposals. Very few adverse criticisms are received, however, as a consequence of publication in THE JOURNAL, although many favorable comments and inquiries are received in reference to the work in progress.

It is the policy of the Society to give currently through THE JOURNAL comprehensive information on the activities of the Divisions of the Standards Committee. Members of the Society should appreciate, however, that so far as the Standards Committee is concerned, reports or recommendations have no irrevocable Society standing prior to approval at a duly called meeting of the Society. Through THE JOURNAL Society members receive ample opportunity to comment on all recommendations that may or may not eventually become S. A. E. Standards and Recommended Practices. The printed word is used because it is cheaper to circularize the Society members by use of it rather than by general circular letters.

The "Licensing" of Engineers

BY direction of the Council, a general letter was sent to the members recently on the subject of the laws that have been passed in a score of States providing in general that engineers doing public or private engineering work of a responsible nature shall be required to register, paying fees of varying amounts up to $25 for first registration.

The purpose of the Council was to serve the members by calling their attention to the subject generally, for the reason that to a surprising extent engineers have been unaware of the existence of these laws, most of which have been in legal effect for some time. A great difference of opinion naturally exists as to the advisability, fairness and effectiveness of the laws. Many stress the fact that the licensing practice in various professions has not been highly beneficial so far as the ability and integrity of their members as a whole are concerned. Some feel that engineers need adequate protection and that suitable laws would provide this as well as tend to increase the remuneration for their work. One member expresses the opinion that "for the training, intelligence and hard work that he does, the engineer is the most underpaid man." Another states, "The idea of the laws is to protect the public against 'malicious' engineering, but they do not in any way provide the public with means to assure that sound, conservative and proved engineering talent will be at its command." Of course, the political aspect of the licensing of engineers is a large factor.

The fact is that there is a wide divergence of opinion, as well as greatly varying information, on the whole question among engineers. The question is a very broad one. This is the reason that the engineering profession has been anything but distinctly articulate in definite attitude toward and expression of opinion on the matter of the laws in question, through engineering societies or affiliated bodies. There is very little evidence of injury to the public from poor work by engineers.

It is understood that the scope of the law of the State of New York passed some time ago, requiring the registration of engineers, has been much restricted owing to the passage recently of a bill stipulating that men holding positions of a certain class with companies engaged in interstate commerce shall not be required to register.

Capitalize Truck Operators Experience

SEVERAL educational institutions have addressed inquiries to the Society asking for recommendations of authoritative textbooks on commercial automotive transportation. These institutions are finding a demand for comprehensive courses for motor-transport engineers. It has been necessary in every instance to reply that no thorough and scientific treatise has been prepared, where the knowledge and experience of successful motor-transportation operators may be found assembled in concrete form. This situation brings to mind the importance of our commercial vehicle engineers turning their attention to the operating end of the business. This is more particularly true of freight than passenger traffic, for we find the two companies who pioneered motorbus and taxicab transportation both firmly established as operators in their respective fields. They have learned the lessons of operation and are in a position to pass them on to purchasers of their equipment.

The construction of sound operation practice in the truck field has been left largely to the operator to work out. Sometimes he has had the assistance of the truck builder's sales department, but seldom has he been afforded engineering guidance. Many of the studies made by operators represent well-planned, productive pieces of research that have led to the accomplishment of cheaper transportation and the establishment of the motor truck and the motorbus as efficient commercial carriers. This work of the operator is responsible as much as any other factor, for the apparent impetus given automotive transportation in the past year.

The truck builder and his engineers must get closer to the operating end of motor transport. Design and operation are so closely allied that this intimate relation is essential to the success of the business. Engineers must attend operators' conventions; they must visit and consult with the operators of large fleets; they must see the effect of usage on their vehicles by personal visits to large maintenance stations. Suitable loading and unloading devices cannot be visualized in one's office; accessibility cannot be carried to the ultimate state on the drafting board, or even in the experimental shop. Personal impressions on the spot give one a new vision and an incentive to progress. They enable us to keep in advance of the art rather than merely keeping pace with it. Let us mix more personal observation of truck operation with our engineering thought. Every trip, every visit, every inspection will enable us to carry home some one impression that will pay the expense bill and usually it will be an idea that could never have germinated within our own four walls. When we have the operator's picture and his experience let us put it into concrete form where it may be available for others.

Economic Motor-Fuel Volatility

By STEPHEN M. LEE[1]

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

THE paper is a progress report supplementing a previous report made by R. E. Carlson on the same subject and covers further investigations made by the Bureau of Standards to secure data that can be used as a basis for estimating the effect of a change in the gasoline volatility on the fuel-consumption of cars now in service throughout the United States. Actual tests began in August, 1922, to determine the effect of four fuels of different characteristics on the number of car-miles obtainable per gallon of fuel, as well as on the crankcase-oil dilution. The earlier paper discussed tests run in summer time. The present paper treats those run under winter conditions. Observations also were made on an engine which was set-up and operated in the laboratory under test conditions.

Descriptions are given of the fuels used, the test-cars, the apparatus, the tests and the test methods. The paper also covers a continuation of the crankcase-oil-dilution investigation, with appropriate accompanying data. The results are discussed briefly.

THIS paper is a progress report of the fuel investigation now being conducted by the Bureau of Standards in cooperation with the American Petroleum Institute, the National Automobile Chamber of Commerce and the Society of Automotive Engineers. This investigation was undertaken to secure data to be used in estimating the effect of changes in gasoline volatility, within a given range, upon the performance of the automobiles now in service in this country. The range of volatility was determined by the specifications of four test-fuels selected as described in previous reports. While fuel economy was the phase of car performance chiefly considered, flexibility of operation and crankcase dilution were included as having an important bearing on the problem.

The primary reason for this investigation arises from the difficulty of meeting the rapidly increasing demand for motor fuel from the crude-oil production that has been increasing far less rapidly. According to the figures given by Dr. Van H. Manning in a paper at the Second Annual Meeting of the American Petroleum Institute, during the 5-year period from 1914 to 1919 there was an increase in automobile registration of more than 300 per cent, an increase in gasoline production of over 200 per cent and an increase in crude-oil production of but 42 per cent. This increased production of gasoline has been made possible by refining a greater proportion of the crude oil produced, by the use of more efficient oil-refinery distillation-equipment, by the addition of casinghead gasoline, by the employment of the cracking process and by including in the gasoline increasing amounts of less volatile fractions. This last method is the most important and in it lies the reason for this investigation.

These less volatile hydrocarbons possess somewhat greater energy per unit volume than the more volatile, but the current opinion is that this energy is not so readily or efficiently transformed into useful work in existing automobile engines as is the case with the more volatile distillates. In fact, it has been held that the economic limit has been reached; that a further increase

[1] Jun. S. A. E.—Assistant mechanical engineer, automotive power-plants section, Bureau of Standards, City of Washington.

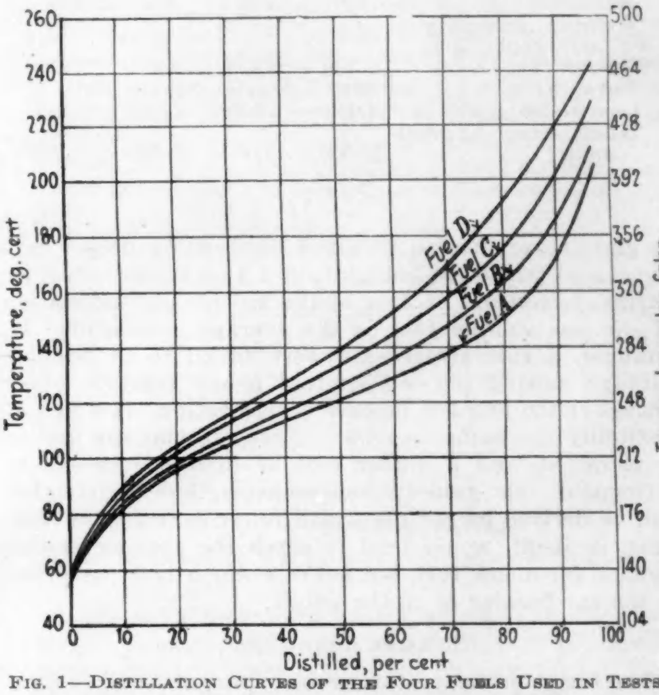

FIG. 1—DISTILLATION CURVES OF THE FOUR FUELS USED IN TESTS

TABLE 1—PHYSICAL CHARACTERISTICS OF THE FOUR TEST-FUELS

	Fuel							
	A		*B*		*C*		*D*	
	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Distillation, Initial	49.0	120	52.0	126	51.5	125	54.5	130
10 Per Cent......	83.0	181	83.5	182	84.5	185	89.0	192
20 Per Cent......	94.0	201	96.3	205	102.0	216	104.5	221
30 Per Cent......	105.0	221	106.7	225	113.5	237	116.0	241
40 Per Cent......	113.5	237	116.3	241	124.5	257	128.0	262
50 Per Cent......	121.0	250	126.2	259	134.0	275	139.0	282
60 Per Cent......	130.0	266	136.0	277	145.0	293	153.0	307
70 Per Cent......	139.5	284	148.0	298	159.0	318	170.5	338
80 Per Cent......	149.5	302	163.7	327	176.5	351	194.0	381
85 Per Cent......	158.0	316	172.0	342	186.0	367	204.0	399
90 Per Cent......	171.5	342	185.0	365	201.0	394	218.5	426
95 Per Cent......	192.0	378	203.0	397	218.0	424	233.0	452
End, or High Point....	206.5	403	214.0	417	229.5	446	244.5	472
Average Boiling-Point .	121	250	125	257	135	275	142	288
Equilibrium Temperature[2]	151	304	163	325	176	349	192	378
Dew-Point, 12 to 1 Mixture[2]	11	52	31	88	47	117	67	153
Average Molecular Weight[3]	111.5		114.0		119.5		123.5	
Specific Gravity at 26 Deg.Cent.(78.5 Deg. Fahr)	0.727		0.733		0.736		0.740	
Index of Refinement, (26 deg. Cent.=78.5 Deg. Fahr.)	1.4110		1.4110		1.4150		1.4165	
Viscosity at 26 Deg. Cent. (78.5 Deg. Fahr.), centipoises..	0.527		0.533		0.577		0.592	
Doctor Test..........	Sweet		Sweet		Sweet		Sweet	
Unsaturated Compounds, per cent.....	5.5		6.5		6.0		6.0	
Moisture Content.....	None		None		None		None	
Acidity..........	None		None		None		None	
Reaction Test..........	None		None		None		None	

[2]Wilson's Method.

TABLE 2—CHARACTERISTICS OF TEST-CARS USED

Car	*W*	*X*	*Y*	*Z*
Year	1920	1920	1920	1920
Number of Cylinders	6	4	4	4
Bore, in.	3⅜	3 11/16	3⅞	3¾
Stroke, in.	4½	4	4½	4
Piston Displacement, cu. in.	241.6	171.0	212.0	177.0
Power Rating[a], hp.	27.30	21.75	24.03	22.50
Wheelbase, in.	118	102	114	100
Weight, Including Equipment and Crew, lb.	3,760	2,450	3,210	2,335
Tires, in.	33x4	30x3½	32x3½	30x3½
Gear-Ratio	4.000	3.670	4.166	3.630
Miles Run, Approximate	15,000	10,000	15,000	12,000

[a] Based on the National Chamber of Commerce formula.

in gasoline production obtained by "cutting deeper into the crude" would not bring about a gain in car miles per barrel of crude oil because of the less efficient utilization of the less volatile fuel by the average automobile. If, however, a substantial gain were found to be possible through raising the end-point of motor gasoline, other phases of the problem deserve consideration. If a loss of flexibility in engine operation, chiefly in starting and in acceleration, and a higher cost of maintenance are to accompany this gain in fuel economy, less satisfaction will be derived by car users and fewer cars will be sold. This, in itself, would tend to check the ever-increasing demand for motor fuel, but not in a way attractive either to the car builder or to the public.

Summer Road-Tests

The investigation of this problem was undertaken on a cooperative basis by the Bureau of Standards in the spring of 1922. The results of the tests conducted during that year were presented at the 1922 Annual Meeting of the American Petroleum Institute and at the 1923 Annual Meeting of the Society. The work had consisted chiefly of road-tests under warm-weather conditions, using four cars of makes that were estimated to represent 75 per cent of the total number of cars in use and four specified fuels of varying volatility. Descriptions of these cars and fuels will be found in Tables 1 and 2 and in Fig. 1.

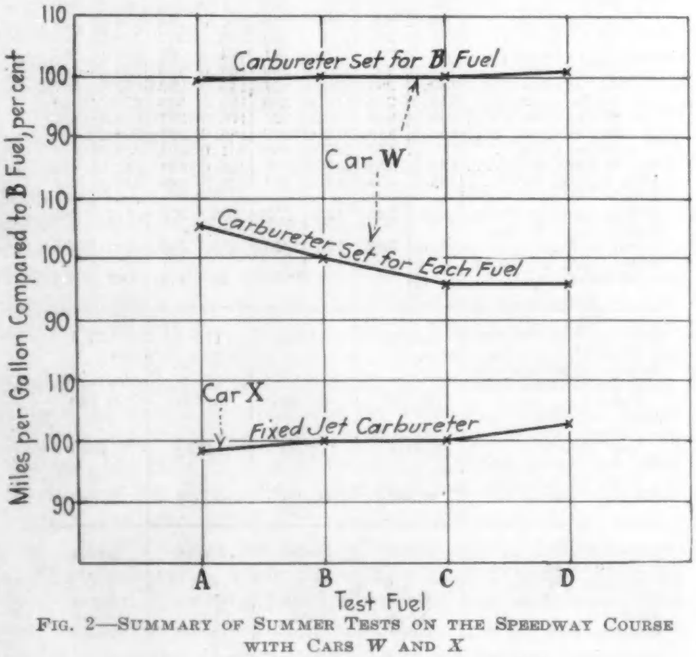

FIG. 2—SUMMARY OF SUMMER TESTS ON THE SPEEDWAY COURSE WITH CARS *W* AND *X*

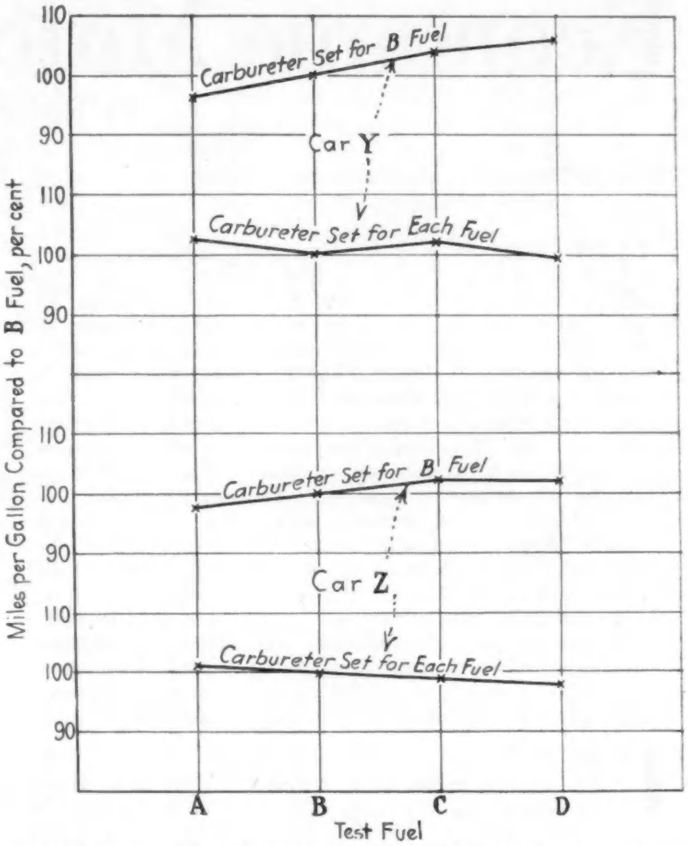

FIG. 3—SUMMARY OF SUMMER TESTS ON THE SPEEDWAY COURSE WITH CARS *Y* AND *Z*

Laboratory work with the engine of the car in most general use was undertaken upon the completion of the road-tests.

The results of the summer road-tests on the Speedway course are summarized in Figs. 2 and 3. The conclusions drawn from these results are (*a*) that under summer weather conditions the differences in fuel consumption obtained with the four test-fuels were much smaller than the differences in the estimated possible production of these test-fuels by current methods as indicated in Table 3, and (*b*) that the results were sensitive to small changes in carbureter adjustment. This sensitiveness is illustrated by the fact that, with a fixed adjustment, better economy was obtained with the less volatile fuels; whereas, when the carbureters were adjusted for each fuel, somewhat better economy was obtained with the more volatile fuels.

The results of the road tests for crankcase dilution indicate that there was a greater rate of dilution with the less volatile fuels.

The Advisory Committee representing the American Petroleum Institute, the National Automobile Chamber of Commerce and the Society of Automotive Engineers, then decided to continue this cooperative program so as

TABLE 3—ESTIMATED PRODUCTION OF FOUR TEST-FUELS, COMPARED WITH GRADE-*B* FUEL

Refiner	Fuel *A*	Fuel *B*	Fuel *C*	Fuel *D*
1	81	100	114	128
2	91	100	111	124
3	83	100	113	122
4	84	100	115	133
5	90	100	112	145
Average	86	100	113	130

to compare the fuels under winter conditions. It was the desire of the Committee that the scope of the program be broadened so as to include a study of those conditions of operation that have a major influence on economy, dilution, acceleration and starting.

In carrying out this program, an effort has been made first to obtain data that would identify those conditions under which differences between the fuels would be most apparent, and then to obtain indications of the relative magnitude and importance of such differences. Upon the completion of this survey, it was planned to investigate more thoroughly the factors controlling these more important differences. Up to the time of this report, the conditions under which differences in the fuels affect

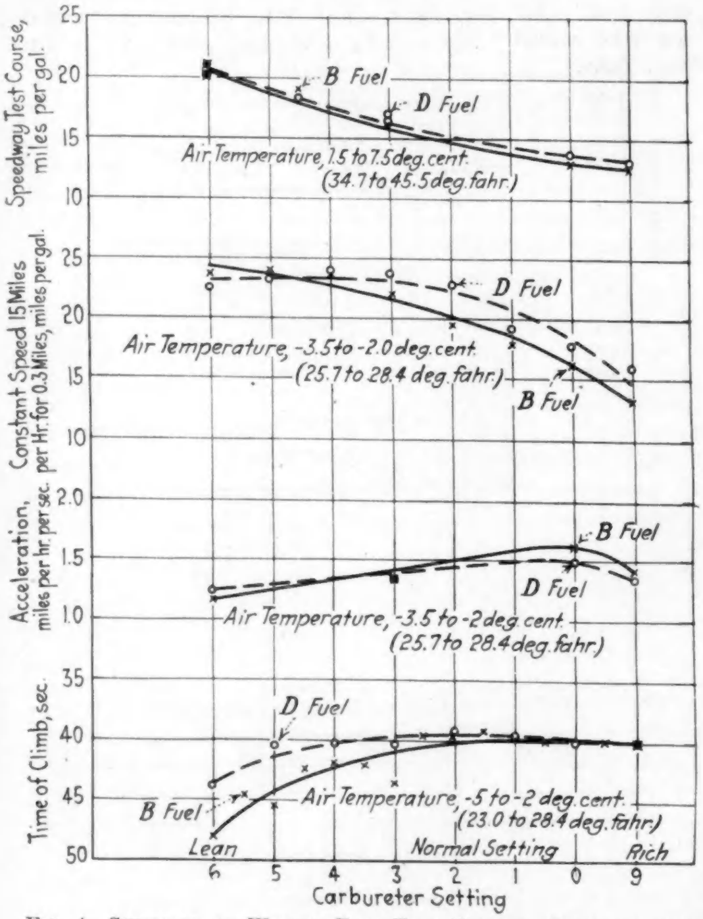

FIG. 4—SUMMARY OF WINTER ROAD-TEST RESULTS OBTAINED WITH CAR *W*

economy at constant speed and load and crankcase dilution have been identified. Similar surveys of the conditions of acceleration and ease of starting are now in progress. In the survey herein reported, gaps may therefore be apparent, which it is hoped can be filled after subsequent work.

WINTER ROAD-TESTS

The winter road-tests were made with cars *W* and *Z* and with fuels *B* and *D*. The cars were driven over the Speedway test-course of 3.2 miles in the same manner as in the summer runs. It will be remembered that this procedure involved successive accelerations or decelerations at 0.1-mile intervals. However, these winter runs were made at five different carbureter settings; whereas the summer runs were made with but two. A fuel-consumption comparison over a wide range of carbureter settings was secured thereby. Level-road acceleration and hill-climbing runs were made also to identify these carbureter settings and to compare the available power and acceleration when using these fuels. The air temperature during these runs varied from —5 to +7 deg. cent. (23 to 45 deg. fahr.).

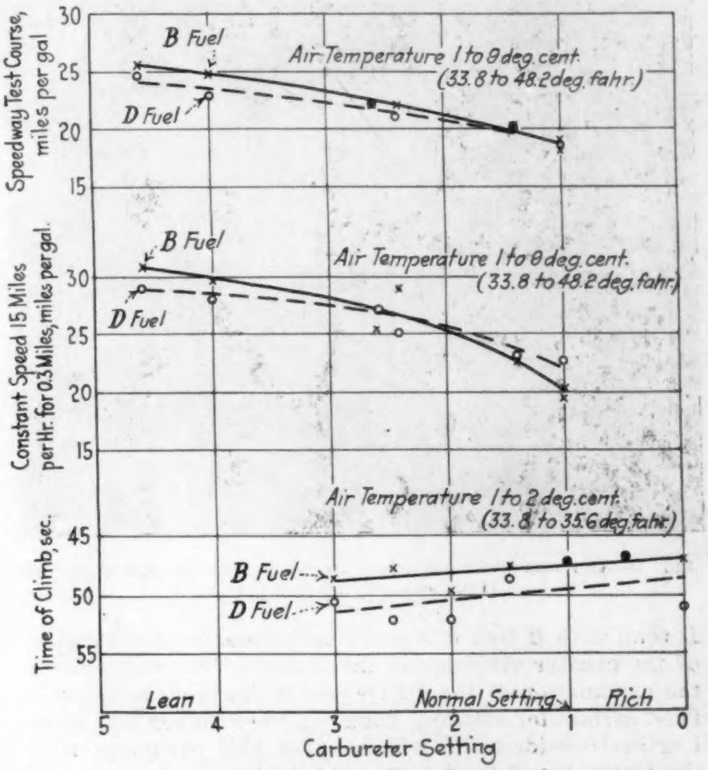

FIG. 5—SUMMARY OF WINTER ROAD-TEST RESULTS OBTAINED WITH CAR Z

The results of these tests shown in Figs. 4 and 5 are erratic, probably due to the wide variation in engine temperatures and due to wind. They do not evidence consistent and significant differences in fuel economy or any other phase of performance as between the test-fuels. The apparent differences are that at constant speed and with very lean carbureter-settings the fuel consumption with *B* fuel is less than with *D* fuel, but that the reverse is true at carbureter settings for normal use. This may be due to the fact that a leaner mixture is obtained with

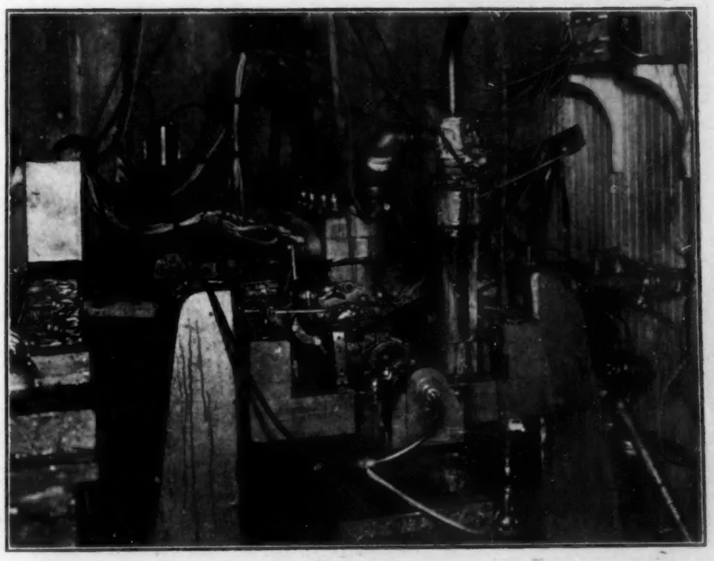

FIG. 6—END VIEW OF THE ENGINE FROM CAR Z BEING TESTED IN THE LABORATORY

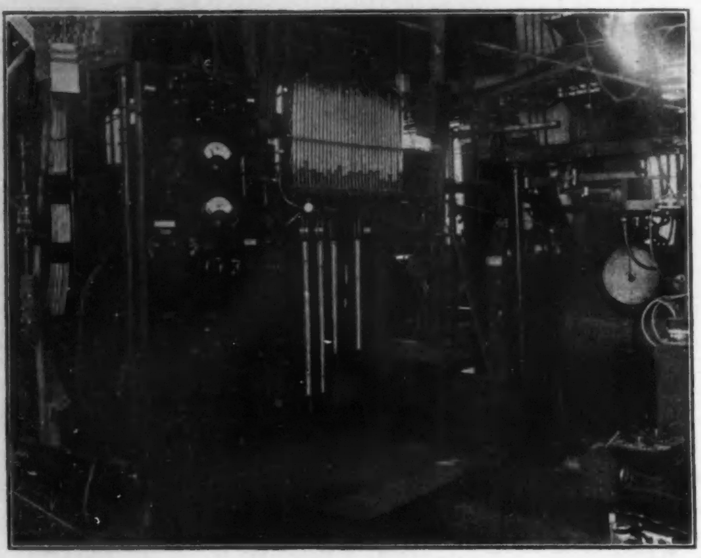

FIG. 7—ANOTHER VIEW OF THE LABORATORY SET-UP SHOWING THE DYNAMOMETER AT THE LEFT

D than with *B* fuel at a given carbureter-setting because of the greater viscosity of the *D* fuel. This may also be the explanation of the differences in fuel consumption at fixed carbureter-settings, found in the summer test-runs. Further consideration will be given this phenomenon in the discussion of the laboratory tests.

The results of the winter road-tests are then in general agreement with those of the summer test. For the foregoing reason and because of the impracticability of making a study of the relative effects of the various operating conditions when all the conditions are varying widely, it was decided to concentrate time and effort upon the engine set-up in the laboratory. The easy control and the accurate measurement of the temperatures, the speed and the load possible in such a set-up offered a much better opportunity for studying the factors that dominate in the effect of fuel volatility upon consumption, crankcase dilution and the like.

LABORATORY TESTS

Photographs of the engine set-up are shown in Figs. 6, 7 and 8. As may be seen in Fig. 7, a disc was mounted

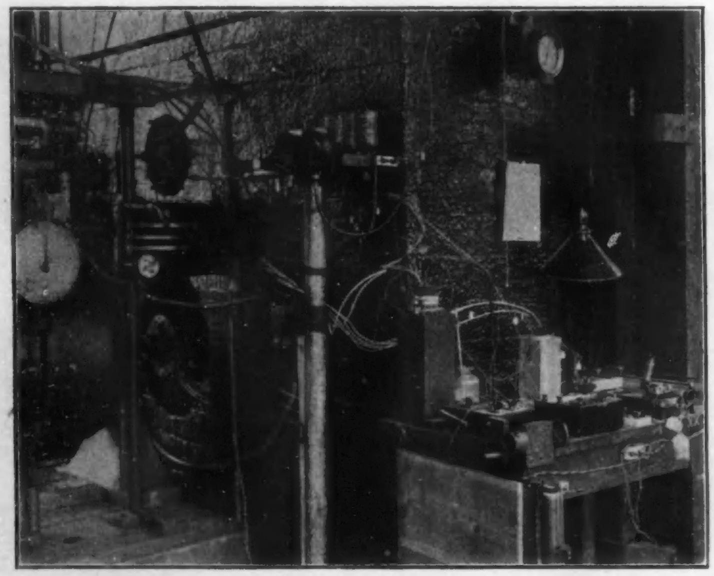

FIG. 8—ANOTHER VIEW OF THE LABORATORY SET-UP

on the end of the armature shaft of the dynamometer so that the inertia load of the shaft, the armature and the disc is approximately equal to that of the car *Z* from which the engine was taken.

FUEL-CONSUMPTION TESTS AND RESULTS

Many trial runs were made with the four test-fuels under conditions covering a wide range of air temperature, circulating-water temperature, mixture-ratio, speed and load. The runs constituting the most complete set were with *B* and with *D* fuel, at full and at part load at engine speeds of 500 and 800 r.p.m. and at full load only at 1200 r.p.m. for each fuel, respectively. Five carbureter-settings were used for each run. The temperature of the outlet jacket-water was maintained constant at 10 deg. cent. (50 deg. fahr.) and that of the carbureter air was varied from —5 to +65 deg. cent. (23 to 149 deg. fahr.).

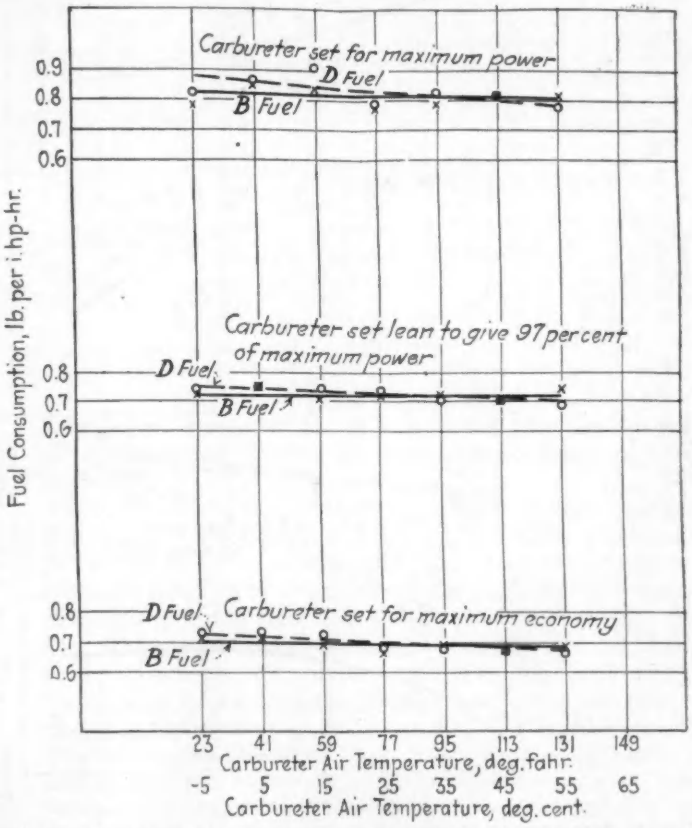

FIG. 9—COMPARISON OF THE AMOUNTS OF *B* AND *D* FUEL CONSUMED AT A SPEED OF 500 R.P.M. AND FULL THROTTLE

With each speed, load, air temperature and fuel, a mixture-ratio run was made; that is, the carbureter was adjusted for what appeared to be a maximum-power mixture, and the fuel consumption was taken with that setting. Then, two leaner and two richer settings were used also.

The results of these fuel-consumption tests are given in Figs. 9 to 13 and include full-throttle operation at 500, 800 and 1200 r.p.m. and part-throttle operation at 500 and 800 r.p.m. The power output is not given, because it was approximately the same with either fuel. There was, of course, greater power-output at the lower air-temperatures.

It can be seen readily that there usually is no difference in fuel consumption as between the test-fuels *B* and *D* at either maximum-power or maximum-economy carbureter-settings. There is one exception. The results of runs at 500 r.p.m., at part load, shown in Fig. 12, in-

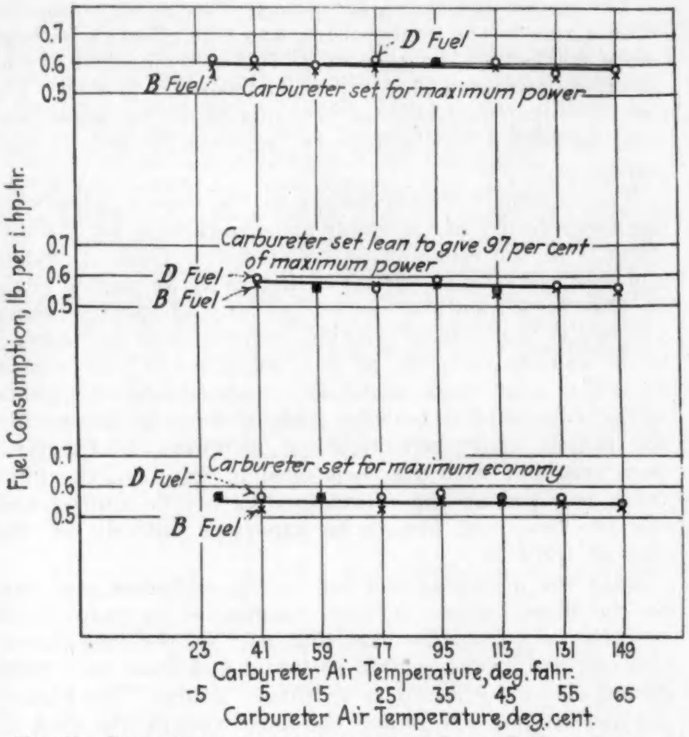

FIG. 10—COMPARISON OF THE AMOUNTS OF *B* AND *D* FUEL CONSUMED AT A SPEED OF 800 R.P.M. AND FULL THROTTLE

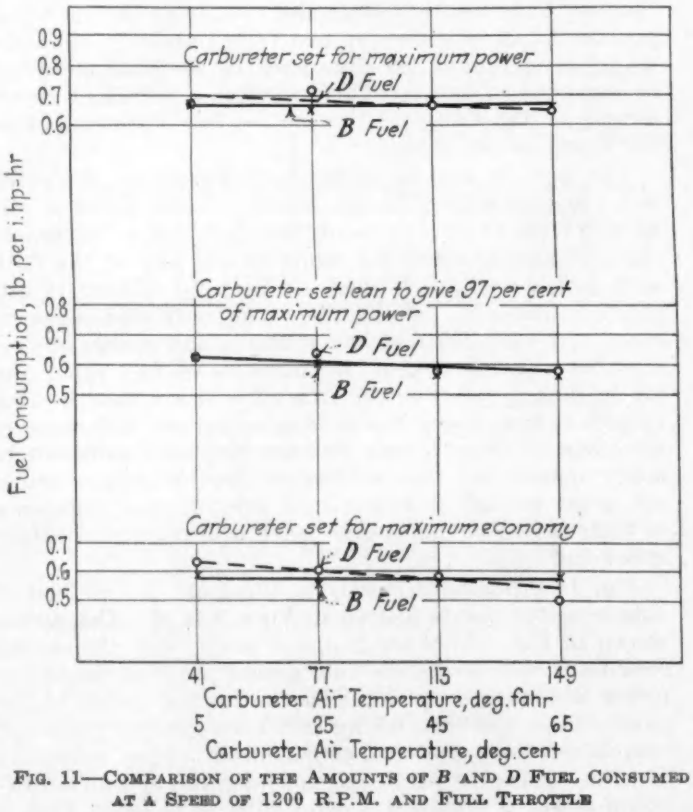

FIG. 11—COMPARISON OF THE AMOUNTS OF *B* AND *D* FUEL CONSUMED AT A SPEED OF 1200 R.P.M. AND FULL THROTTLE

dicate greater fuel-consumption with *D* than with *B* fuel. This difference varies from about 10 per cent at —5 deg. cent. (23 deg. fahr.) to practically zero per cent at 65 deg. cent. (149 deg. fahr.). Further investigation of this condition of operation seems desirable as it appears to be of importance in the normal operation of the car under winter starting conditions. The results seem to show that with this engine and under conditions of low speed and temperature, more of *D* than of *B* fuel is required to give a maximum-power mixture or to operate at all. If the carbureter were set for constant-speed operation under these conditions, the consumption of the less-volatile fuel probably would be greater under other conditions also. If, on the other hand, the carbu-

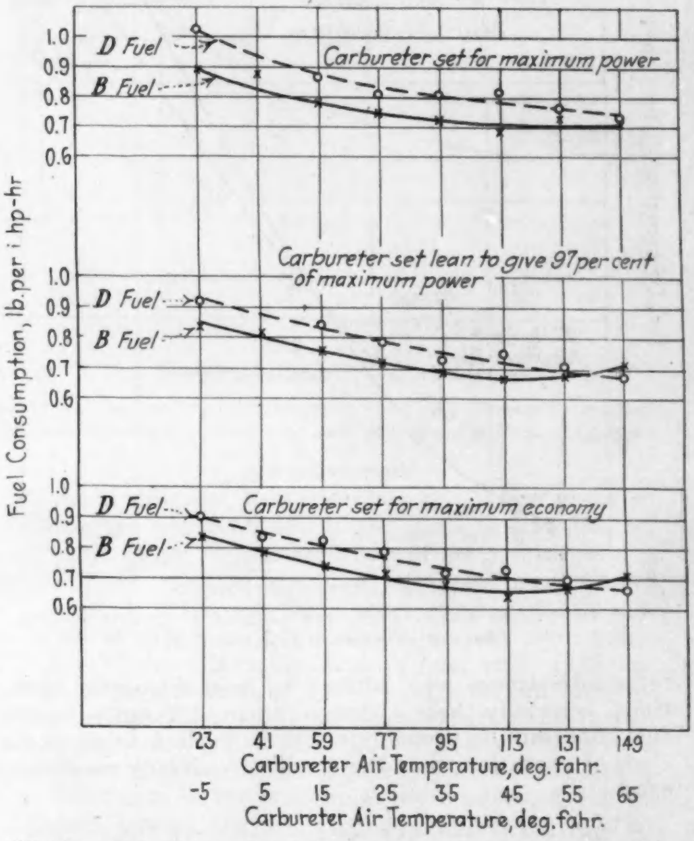

FIG. 12—COMPARISON OF THE AMOUNTS OF *B* AND *D* FUEL CONSUMED AT A SPEED OF 500 R.P.M. AND PART THROTTLE

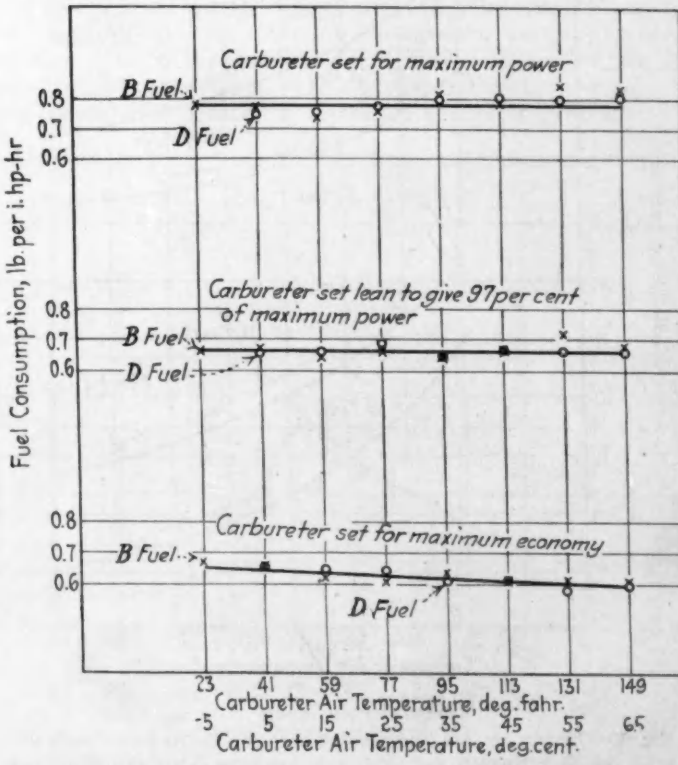

FIG. 13—COMPARISON OF THE AMOUNTS OF *B* AND *D* FUEL CONSUMED AT A SPEED OF 800 R.P.M. AND PART THROTTLE

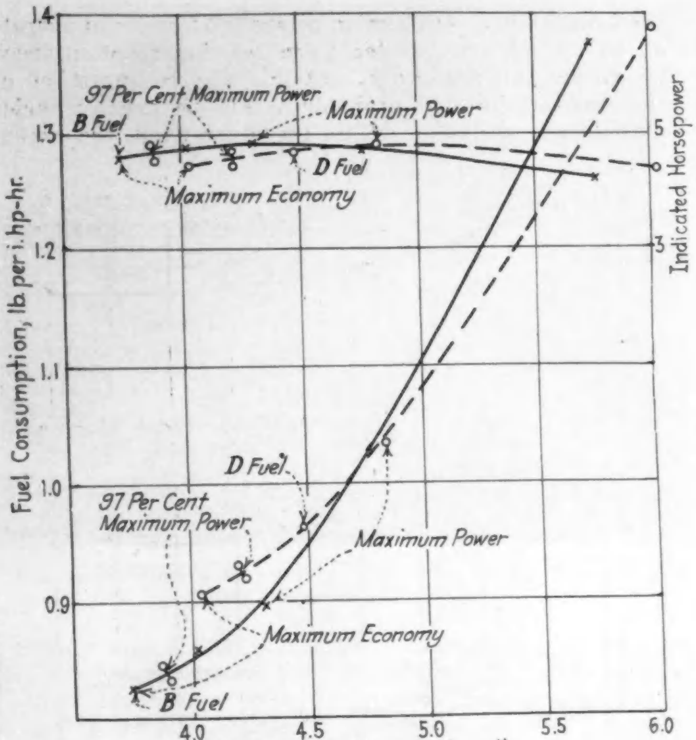

FIG. 14—CURVES ILLUSTRATING THE METHOD OF OBTAINING THE POINTS PLOTTED IN FIGS. 9 TO 13

reter adjustment were altered to meet changing conditions, especially those of temperature, differences in the fuel consumption probably would be limited to those periods of operation when the conditions already mentioned exist.

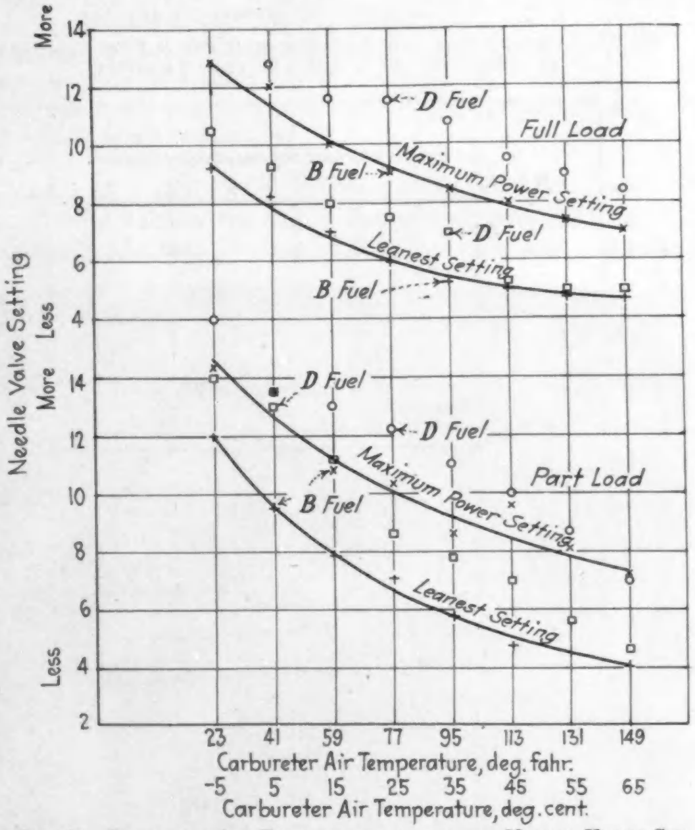

FIG. 15—EFFECT OF AIR TEMPERATURE UPON THE NEEDLE-VALVE SETTING FOR THE MAXIMUM-POWER AND LEANEST AIR-FUEL RATIOS AT A SPEED OF 500 R.P.M.

The results indicate a decrease in the fuel-consumption with a rise in the temperature, and this effect is perhaps more marked in the case of *D* fuel as evidenced by the greater downward slope of the curves for *D* fuel. The temperature effect is most pronounced at that speed and load at which the difference between *B* and *D* fuel appeared.

The reasons for this change in the consumption with the temperature are probably also the reasons for the difference in the economy as between two fuels of widely different volatilities. If all cylinders of an engine could be filled with identically equal mixtures of gasoline vapor and air at the time of ignition, regardless of air temperature and the volatility of the fuel, there is little reason to believe that there would be an appreciable difference in fuel consumption between fuels or temperatures within the ranges under consideration. However, at the temperatures and with the fuels used in this test, the mixtures received by the cylinders may not be similar and the fuel may not always be vaporized entirely by the time of ignition.

That the mixtures received by the cylinders may not be the same, either between themselves or from cycle to cycle, is due to the fact that part of the fuel passes through the intake system as liquid and most manifolds do not distribute liquid as uniformly as gas. The higher the air temperature is and the more volatile the fuel is, the less will be the amount of liquid to be distributed and the more uniform will be the distribution. It should be realized, however, that when the conditions are such that practically all of either of two fuels passes through the manifold as liquid, no difference in distribution would be expected as between the fuels, for a manifold should distribute the liquid of the one no less uniformly than the liquid of the other.

The less the amount of liquid fuel entering the cylinder, the greater will be the likelihood that all of it will be vaporized in time to be utilized fully. It is recognized that for normal operation temperatures any of the fuels with which we have to deal can be fully utilized in any single cylinder. It is seen then that, with cold temperatures and with fuels of low volatility, an excess of fuel must be supplied so that the mixtures of fuel vapor and air in each cylinder at the time of ignition shall be rich enough to fire. These tests indicate that the difference in volatility between *B* and *D* fuels, although sufficient to affect appreciably their estimated possible production, is not great enough to result in a very marked difference in their action in this engine when operating at constant speed and load.

Fig. 14 is included merely to illustrate the method of obtaining the points plotted in Figs. 9 to 13. The curves shown in Fig. 14 are for *B* and *D* fuels, with the engine conditions indicated. The fuel consumption at maximum power is obtained by selecting the highest point of the power curve, and then taking the corresponding consumption-value from the fuel-consumption curve vertically beneath. Since the particular consumption at which maximum power is obtained is often difficult to select from a flat power-curve, it sometimes is desirable to use the consumption corresponding to a certain percentage of maximum power to the lean side of the maximum point. The maximum-power value is obtained easily, even though the consumption at which it is obtained is indefinite. The maximum-economy values are, naturally the lowest points of the fuel-consumption curves in the lower part of Fig. 14. The curves in Fig. 14 are the basis of points plotted on Fig. 12 for —5 deg. cent. (23 deg. fahr.).

CONCLUSIONS OF CONSTANT-SPEED FUEL TESTS

The results of the constant-speed tests with the Car-*Z* engine do not show large differences in fuel consumption as between the *B* and *D* fuels. The greatest difference observed was much less than the difference between the estimated possible productions of the two fuels.

It is concluded that the difference in volatility that exists between *B* and *D* fuels is not so large as to produce considerable differences in fuel consumption in existing automobiles, at least under conditions of constant speed and load. Whether or not richer mixtures would need to be used with the less-volatile fuel to obtain equal ease of starting and acceleration is yet to be determined.

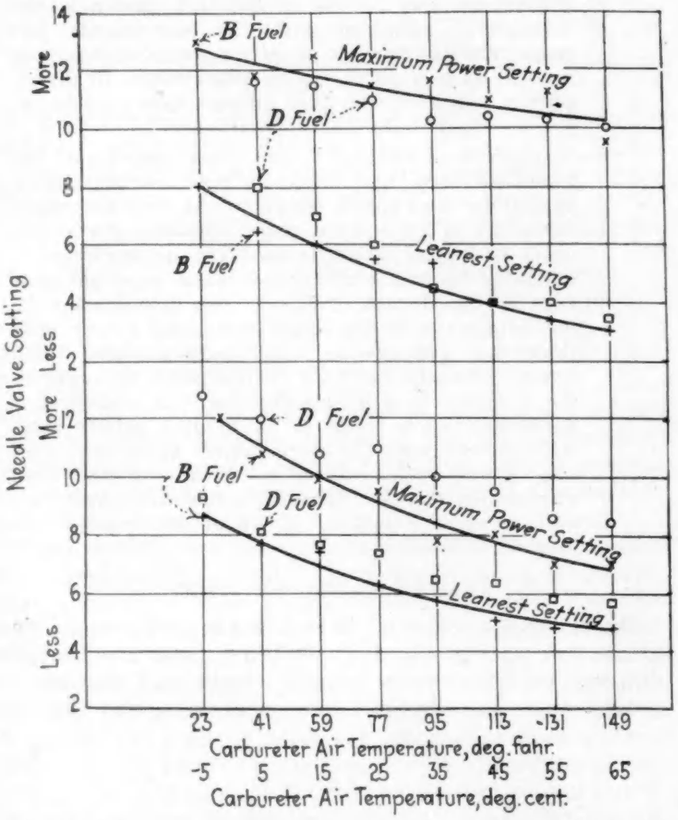

Fig. 16—Effect of Air Temperature upon the Needle-Valve Setting for the Maximum-Power and Leanest Air-Fuel Ratios at a Speed of 800 R.P.M.

It should be remembered in this connection that the accelerations involved in the Speedway tests were accomplished satisfactorily with the less-volatile oils.

AIR-TEMPERATURE AND FUEL-VISCOSITY EFFECTS

Regarding the effect of air temperature and fuel viscosity upon carbureter adjustment, an interesting side-light on the subject of carbureter adjustment is given in Figs. 15 to 17. This may explain many apparent inconsistencies that appear in the fuel tests. These curves were plotted from the data of the fuel-consumption tests just described. They show the needle-valve settings that were made by the operator to obtain maximum power from the engine at each particular carbureter-air temperature. The leanest settings at which the engine would operate regularly are given also. The "needle-valve settings" refer to the position of a dial connected to the needle-valve of the carbureter. The circumference of this dial is divided into 18 parts which are numbered and referred to. The large changes in the needle-valve setting that it was necessary to make to obtain maximum-power

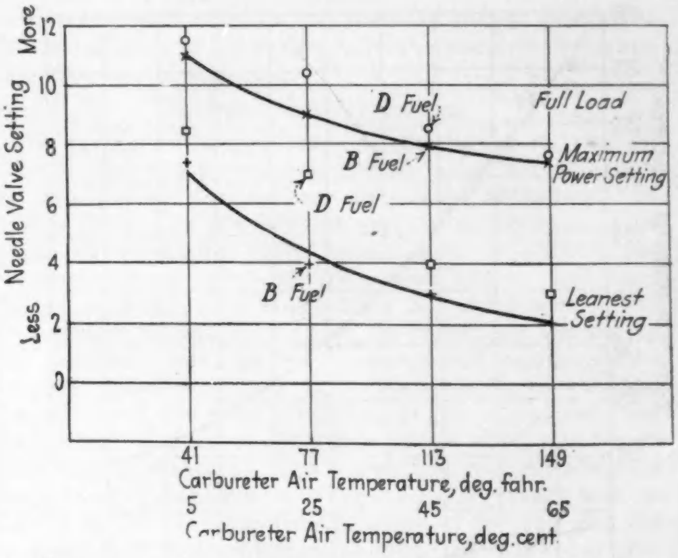

Fig. 17—Effect of Air Temperature upon the Needle-Valve Setting for the Maximum-Power and Leanest Air-Fuel Ratios at a Speed of 1200 R.P.M.

mixtures at different temperatures explain how great an influence the temperatures of the gasoline and the air may have upon the performance of an engine and a carbureter of this type when the carbureter is not altered to meet each change in the temperature. For example, if the carbureter were adjusted for the maximum power with the engine operating at a 65-deg. cent. (149-deg. fahr.) air-temperature, at 500 r.p.m. and full throttle, shown in Fig. 15, and the air temperature subsequently should fall below 13 deg. cent. (55.4 deg. fahr.), the mixture would be so lean that the engine would cease to run. Similarly, if the carbureter were adjusted for the maximum power at a low air-temperature, the mixture would be entirely too rich at the higher air-temperatures. The above indicates the difficulty of obtaining uniformly satisfactory operation without (*a*) varying the carbureter setting to take care of changes in temperature conditions, or (*b*) providing some means of controlling the temperature to agree with a given carbureter-setting. This difficulty is present to almost the same degree with

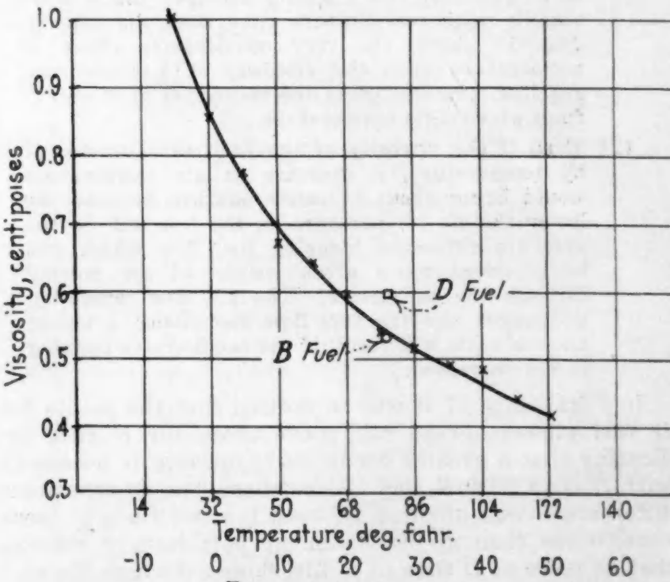

Fig. 18—Effect of Temperature upon the Viscosity of a Commercial Gasoline Having a Specific Gravity of 0.743 at 26 Deg. Cent. (78.8 Deg. Fahr.)

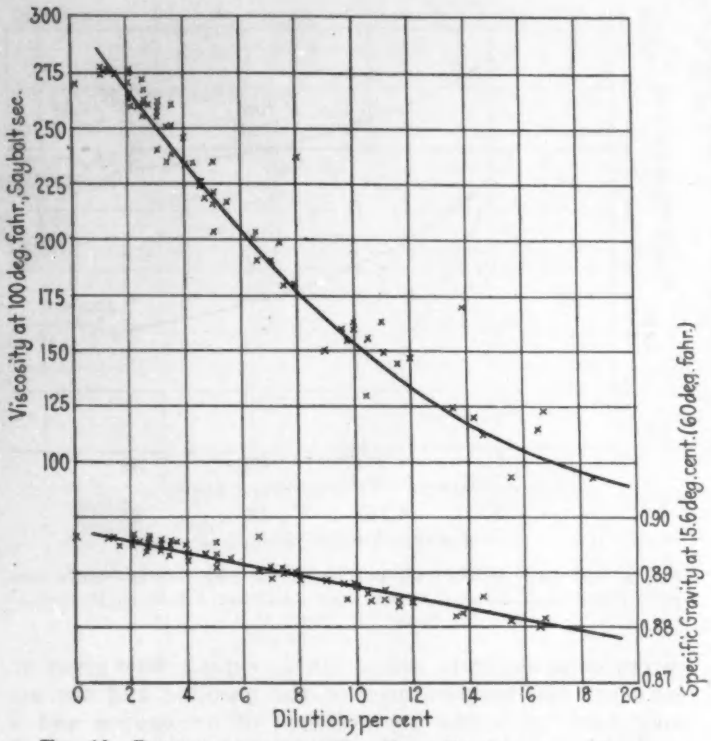

FIG. 19—RELATION BETWEEN PER CENT DILUTION AND SAYBOLT VISCOSITY OF THE OIL USED

any of the fuels used in these tests but is undoubtedly less with carbureters in which fuel viscosity has but little effect.

The reasons, other than difference in efficiency of fuel utilization, why the needle-valve opening must be increased to give a maximum-power mixture when the air temperature is decreased, seem to be as follows:

(1) The lower the *fuel temperature* is, the greater will be its viscosity; and the greater the viscosity is, the less the flow will be, other conditions remaining the same. To maintain a constant air-fuel ratio, this effect must be compensated for by an increase in needle-valve opening. The increase in fuel density with a decrease in the temperature tends to compensate for this viscosity effect, but, with gasoline, the viscosity changes much more rapidly with temperature than does the density. Fig. 18 shows the very considerable effect of temperature upon the viscosity of a commercial gasoline, and also gives the viscosities of *B* and *D* fuels at a single temperature.

(2) Even if the viscosity of the fuel were unaffected by temperature, a decrease in air temperature would bring about a leaner mixture because the lower the air temperature is, the less will be the pressure difference inducing fuel flow which will be produced by a given weight of air flowing through the carbureter. The air flow remaining unchanged and the fuel flow decreasing, a leaner air-fuel ratio will result if the needle-valve opening is not increased.

In Figs. 15 to 17 it will be noticed that the points for *D* fuel almost always fall above those for *B* fuel, indicating that a greater needle-valve opening is necessary with *D* than with *B* fuel. Since there was no consistent difference in consumption between the two fuels in these runs, other than at 500 r.p.m. at part load, it follows that no more of *D* than of *B* fuel flowed through the carbureter jet and, hence, the greater needle-valve opening was necessary merely because of the greater viscosity of the *D* fuel. This checks and explains what was found in the summer road-tests; namely, if the carbureter were set for the maximum power with each fuel, the setting for *D* fuel appeared to be richer but no great difference in the number of miles per gallon resulted because there was little change in the fuel flow. If, on the other hand, *D* fuel were used when the carbureter was set for the maximum power with *B* fuel, more miles per gallon but otherwise inferior performance was obtained with the *D* fuel.

Two tendencies of significance are suggested by a consideration of the viscosity effect in carbureters of this type, as follows:

(1) When drivers observe a difference in fuels as regards flexibility, power and acceleration, these differences may be due to the fact that a leaner mixture is obtained with the less-volatile and more viscous fuel at a given carbureter-setting as well as to a difference in vaporization or distribution. In fact, the fuel consumption may be as low or lower under these conditions.

(2) Variations in the distillation characteristics of the gasolines now sold may indicate corresponding variations in viscosity, which would have the effect described in (1). That the distillation characteristics of motor gasoline do vary appreciably is indicated by the semi-annual motor gasoline surveys by the Bureau of Mines. An examination of the data given in the above-mentioned report will show that gasoline is much more uniform than it was formerly, but that the variation throughout the country is still appreciable. If carbureter adjustments are made so as to give satisfactory performance with the more-viscous fuels, then the less-viscous fuels will be used in over-rich and wasteful mixtures. Therefore, fuel uniformity as well as fuel volatility is important insofar as economy is concerned.

CRANKCASE-DILUTION TESTS

By crankcase dilution is meant the addition of fuel to the lubricating oil. It is believed generally that the dilution obtained with present fuels and engines is greater than was obtained some years ago, and that the

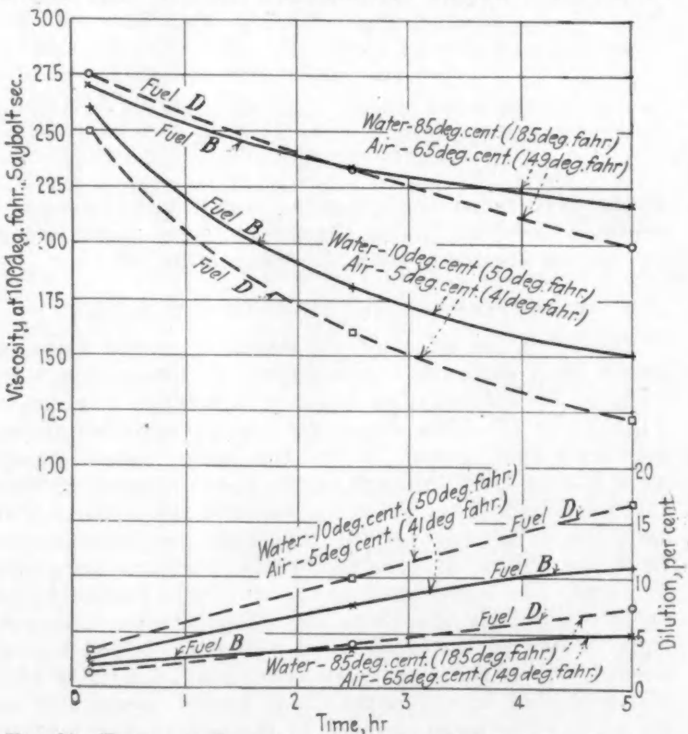

FIG. 20—EFFECT OF FUEL VOLATILITY UPON THE RATE OF DILUTION

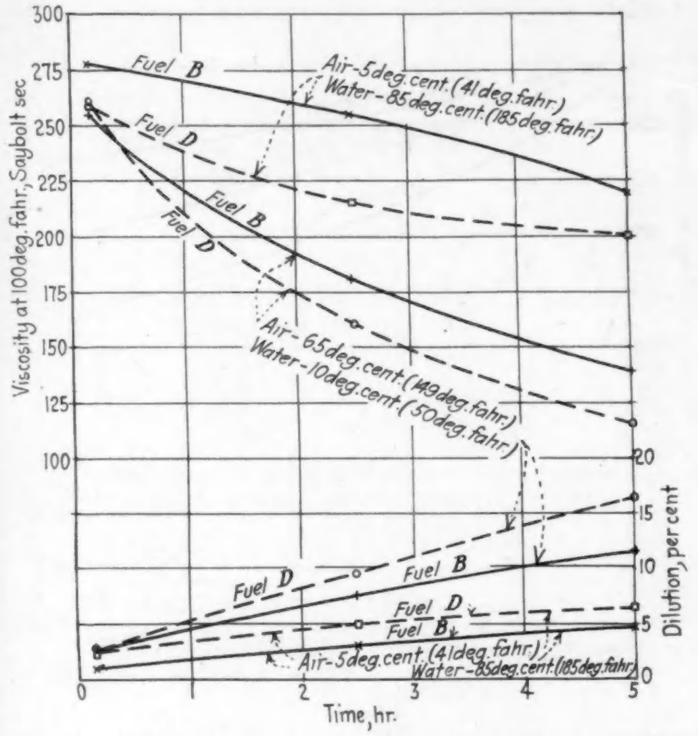

FIG. 21—ANOTHER SET OF CURVES SHOWING THE EFFECT OF FUEL VOLATILITY UPON THE RATE OF DILUTION

decrease in fuel volatility which has taken place is responsible chiefly for the increased dilution. Therefore, the effect of a further decrease in fuel volatility upon the rate of dilution was considered to be an important part of this investigation.

The one well recognized effect of dilution is to diminish the viscosity of the lubricant greatly. Whether it has any other important effect is not definitely known. The viscosity still is regarded as the most important measurable property that an oil possesses and is a fairly reliable indication of the ability of an oil to maintain its lubricating film under all conditions of temperature, pressure and speed. It is desirable to use the least viscous oil that will keep the metal surfaces apart consistently. If the viscosity is less than this, wear of the engine parts will occur during the moments of heaviest load and highest temperature. The less the viscosity, the greater will be the frequency and the duration of these periods of wear. It also is possible that a critical condition of the oil-seal between the piston and the cylinder may exist; that is, when the viscosity of the lubricant falls below a particular value, "blowing-by" and rapid wear may occur. If, on the other hand, an oil of unnecessarily high viscosity is used, the friction losses will be large and the load on the starting motor excessive, because engine friction is largely the resistance to shear of the oil-film on the cylinder-walls and in the bearings, especially the former. It is evident, then, that a rapid rate of crankcase dilution produces a very unstable lubrication condition. If the oil is of correct viscosity at the outset, it will soon be too thin to prevent wear, but if a more viscous oil is used to postpone this condition, a high initial-friction loss is the consequence. The car user is subjected to the nuisance and the expense incident to draining and refilling the crankcase frequently and is often uncertain as to whether he has estimated the rate of dilution correctly.

The summer road-tests for oil dilution indicated a distinctly greater rate of dilution with the less-volatile fuels. The laboratory-test program with the Car-*Z* engine included tests intended not only to compare the rates of dilution obtained with the test fuels but also to determine what conditions of operation have the greatest influence upon the rate of dilution.

DILUTION-TEST PROCEDURE

The procedure adopted for the dilution tests was as follows: The engine was warmed-up, using old oil. During this period, the desired carbureter adjustment, to give as nearly as possible the same mixture-ratio with each fuel, circulating-water temperature and carbureter-air temperatures were secured. The engine was then stopped and the oil drained from the crankcase. Then, 2 qt. of new oil was poured into the crankcase, the engine was motored over, the oil was drained again and a weighed quantity of new oil was poured in. A weighed gasoline-tank was then connected to the carbureter, and the engine was started. The first sample of oil was drawn from the crankcase 10 min. thereafter, without stopping the engine. This sample was considered necessary because the oil in the crankcase at the start of the run was not entirely free from dilution, despite the foregoing procedure. Thereafter, only one more oil-sample was taken until the end of the run, usually a period of 5 hr., so as not to reduce the quantity of lubricant in the crankcase materially. Every effort was made to keep the temperature and the other engine conditions constant. At the end of the run, the crankcase was drained and the contents were weighed; the gasoline tank was weighed also.

All oil-samples were tested as to specific gravity, viscosity and "per cent dilution." The viscosity was obtained with a Saybolt viscosimeter at 37.8 deg. cent. (100 deg. fahr.). The "per cent dilution" was obtained by the following method: A small quantity, 100 cc. of the oil sample, was placed in an Engler distillation flask and heated to the boiling temperature of the new oil, which is 305 deg. cent. (581 deg. fahr.). The products of distillation were condensed and collected in a graduate. The number of cubic centimeters collected in the graduate was called the "per cent dilution." The "per cent dilution" and the Saybolt viscosity at 37.8 deg. cent. (100

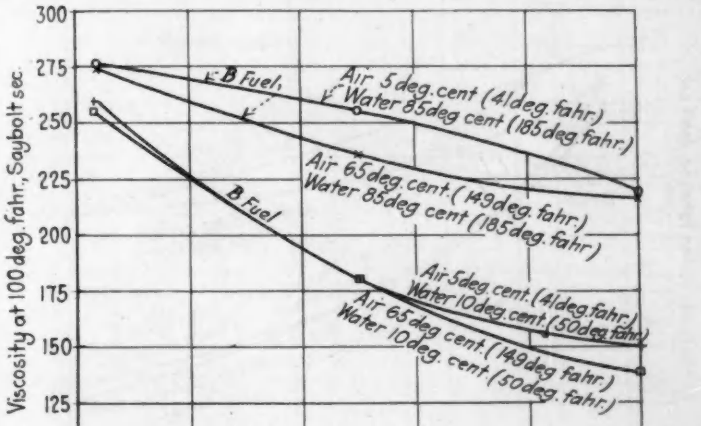

FIG. 22—EFFECTS OF AIR AND WATER TEMPERATURE UPON THE RATE OF DILUTION WITH *B* FUEL

deg. fahr.) of each sample taken in these tests are plotted in Fig. 19. Although there may be some difference of opinion as regards the accuracy of the methods used in determining crankcase dilution, all the results were determined by the same methods with the same oil and are therefore at least comparative.

CRANKCASE-DILUTION TEST RESULTS

Some preliminary runs were made at 600 r.p.m. at full throttle and at part throttle, with *A* and *D* fuels and with several mixture-ratios. A more comprehensive program was then laid-out, of which the runs shown in Table 4 have been completed.

The results of the crankcase-dilution runs are given in Table 5 and in Figs 21 to 27. It should be realized that these results, obtained with but one type of engine and one oil under certain fixed conditions, are not directly applicable to all cases, but that they do indicate general tendencies.

TABLE 4—CRANKCASE DILUTION TESTS

Fuel	Duration, Hr.	Speed, R.P.M.	Load	Mixture Ratio	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Water-Outlet Temperature Deg. Cent.	Water-Outlet Temperature Deg. Fahr.
B, *D*	5	600	Full	Maximum Power	65	149	85	185
				Lean	5	41	10	50
				Rich	65	149	10	50
B	5	600	Full	Maximum Power, Lean, Rich	5	41	85	185
D	5	600	Full	Maximum Power	5	41	85	185
B	5	600	One-Half	Maximum Power	5	41	10	50
B	2	600	Motoring	Maximum Power	5	41	10	50
B	5	1,200	Full	Maximum Power	5	41	10	50
B	15	600	Full	Maximum Power	5	41	10	50

Physical Characteristics of the Oil Used in these Tests

Specific Gravity	0.899		
Baumé, deg	25.7		
Flash Point, deg. fahr	420		
Fire Test, deg. fahr	480		
Pour Test, deg. fahr	25		
	Deg. Cent.	Deg. Fahr.	Saybolt Sec.
Viscosity at	37.8	100	290
	54.5	130	143
	100.0	212	51
Boiling Point	305.0	581	...

[4] See THE JOURNAL, September, 1922, p. 225.

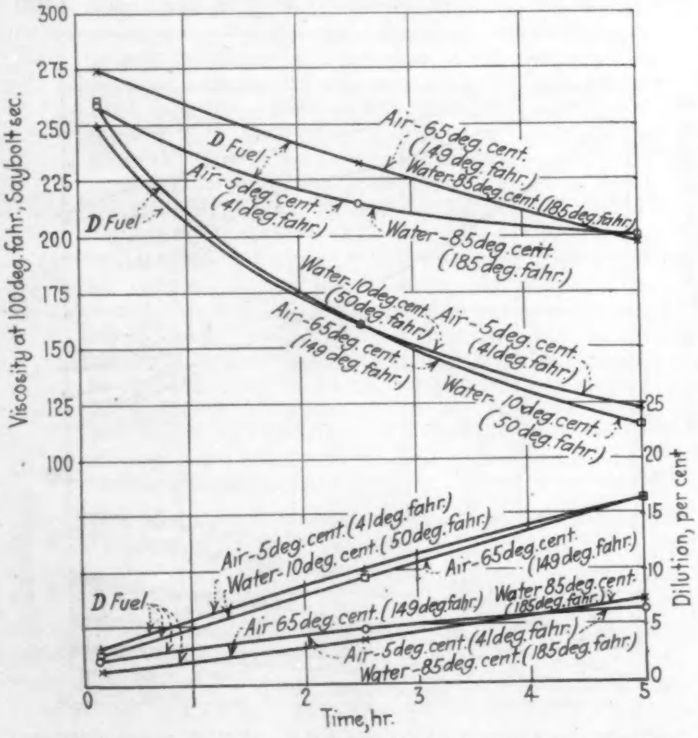

FIG. 23—EFFECTS OF AIR AND WATER TEMPERATURE UPON THE RATE OF DILUTION WITH *D* FUEL

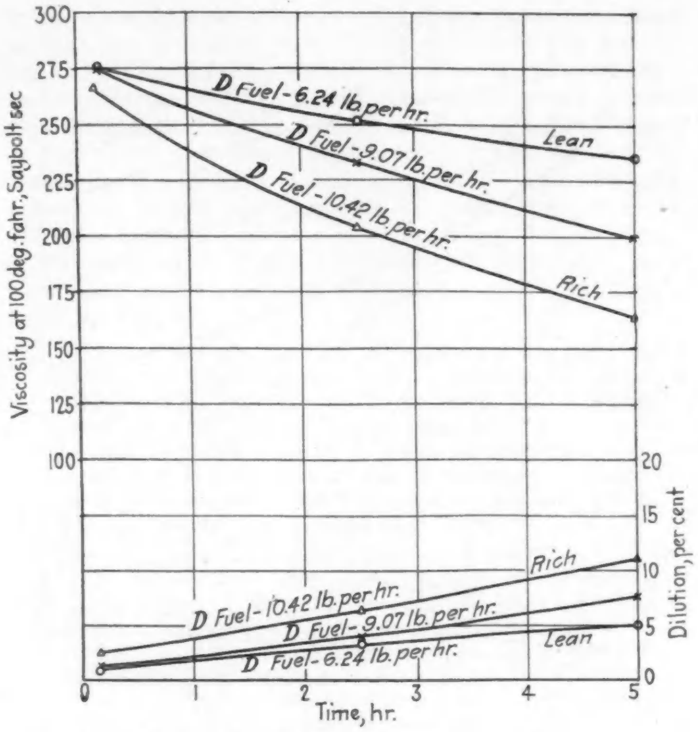

FIG. 24—EFFECT OF MIXTURE-RATIO UPON THE RATE OF DILUTION WITH *D* FUEL

In Figs. 20 to 26, the results of the viscosity and the "per cent dilution" tests of the oil samples taken during the runs are shown. These results are plotted against the time at which the samples were drawn from the crankcase. Figs. 20 and 21 show that a greater rate of dilution was obtained with the less-volatile *D* fuel than with *B* fuel, under each of four combinations of air and water temperature. This difference in rate of dilution is evidenced not only by the viscosity and the "per cent dilution" curves in Figs. 20 and 21, but also by the changes in the amount of lubricant in the crankcase given in the last column of Table 5. The apparent oil-consumption is almost always less with *D* fuel, indicating a greater addition of fuel to the lubricant.

Figs 22 and 23 show the relative effects of carbureter-air and circulating-water temperatures upon the rate of dilution. It is evident that, with this engine and within the given ranges of temperature, the circulating-water temperature had a much greater influence upon the rate of dilution than had the carbureter-air temperature. This result is supported by no less than four runs at each of the four combinations of air and water temperature as shown in Table 4. It should be noted in this connection that the intake-manifold on this engine is cast separately from the cylinder-block and is not hot-spotted; therefore the carbureter-air temperature does determine the charge temperature to a large extent. It is natural to suppose that the air temperature would determine how much or how little of the fuel entered the cylinder in the liquid state and, hence, how great or how little the rate of dilution would be. Also, given a condition where part of the fuel does enter the cylinder as liquid, the higher the piston and the wall temperatures, the greater would be the likelihood of complete vaporization and a low rate of dilution. It has been shown that jacket-water temperatures may have a very considerable influence on piston and wall temperatures, in the piston-temperature measurements given in a paper entitled Aluminum Pistons, by Jehle and Jardine[4].

TABLE 5—DETAILS OF RUNS

No.	Fuel	Per Hr.	Viscosity in Saybolt Sec. of Samples Taken at 10 Min.	2.5 Hr.	5 Hr.	Percentage of Dilution of Samples Taken at 10 Min.	2.5 Hr.	5 Hr.	Change in Weight of Crankcase Contents, Lb.
600 r.p.m. Full Load, Carbureter-Air Temperature, 65 Deg. Cent. (149 Deg. Fahr.); Outlet-Water Temperature, 85 Deg. Cent. (185 Deg. Fahr.)									
1	*B*	8.90	275	234	217	1.5	4.3	5.5	—0.3
2	*D*	9.07	276	233	198	1.3	4.0	7.4	—0.2
3	*B*	6.06	276	260	245	2.0	3.0	3.9	—0.7
4	*D*	6.24	276	251	235	1.2	3.4	5.0	—0.7
5	*B*	10.70	274	203[a]	227[a]	2.0	...	8.5	+0.5
6	*D*	10.42	267	203	163	2.5	6.5	11.0	+0.6
600 r.p.m. Full Load, Carbureter-Air Temperature, 5 Deg. Cent. (41 Deg. Fahr.); Outlet-Water Temperature, 10 Deg. Cent. (50 Deg. Fahr.)									
7	*B*	10.40	261	180	149	2.5	7.8	11.0	+0.7
8	*D*	10.55	251	161	122	3.3	10.0	16.7	+1.2
9	*B*	9.30	261	191	155	2.6	7.0	10.5	+0.7
10	*D*	9.31	272	170	129	2.5	13.8	22.0	+0.8
11	*B*	12.69	259	150	113	3.0	8.9	14.5	+1.2
12	*D*	11.95	260[a]	129	93	3.5	10.4	15.5	+1.6
600 r.p.m. Full Load, Carbureter-Air Temperature, 65 Deg. Cent. (149 Deg. Fahr.); Outlet-Water Temperature, 10 Deg. Cent. (50 Deg. Fahr.)									
13	*B*	9.96	255	179	138	2.5	7.5	11.5	+0.9
14	*D*	10.16	262	160	115	2.5	9.5	16.5	+1.1
15	*B*	8.44	259	191	162	2.1	6.5	9.9	+0.7
16	*D*	8.50	263	237	147	2.0	8.0	12.0	+0.7
17	*B*	12.00	265	155	124	2.0	9.7	13.5	+0.9
18	*D*	11.61	257	144	...	3.0	11.5	....	.....
600 r.p.m. Full Load, Carbureter-Air Temperature, 5 Deg. Cent. (41 Deg. Fahr.); Outlet-Water Temperature, 85 Deg. Cent. (185 Deg. Fahr.)									
19	*B*	9.33	277	255	218	1.0	3.0	4.7	—0.0
20	*D*	9.41	259	216	200	2.3	5.0	6.4	+0.2
21	*B*	8.17	270	240	225	2.0	3.0	4.5	+0.1
22	*B*	10.75	270	238	221	0.1	3.5	5.0	—0.2
600 r.p.m. Part Load, Carbureter-Air Temperature, 5 Deg. Cent. (41 Deg. Fahr.); Outlet-Water Temperature, 10 Deg. Cent. (50 Deg. Fahr.)									
23	*B*	4.48	274	235	220	2.0	3.3	5.0	+0.3
600 r.p.m. Motoring, Carbureter-Air Temperature, 5 Deg. Cent. (41 Deg. Fahr.); Outlet-Water Temperature, 25 Deg. Cent. (77 Deg. Fahr.)									
24	*B*	5.34	203	77[b]	...	5.0	23.0[b]	...	+2.4
600 r.p.m. Full Load, 15 Hr., Carbureter-Air Temperature, 5 Deg. Cent. (41 Deg. Fahr.); Outlet-Water Temperature, 10 Deg. Cent. (50 Deg. Fahr.)									
25	*B*	10.17	262	...	170	1.5	...	9.3	+0.6
25	*B*	....	...	...	121[c]	..	...	14.2[c]	....
25	*B*	....	...	...	93[d]	..	...	18.4[d]	....

[a] Sample contained water.
[b] Sample taken at 2 hr.
[c] Sample taken at 10 hr.
[d] Sample taken at 15 hr.

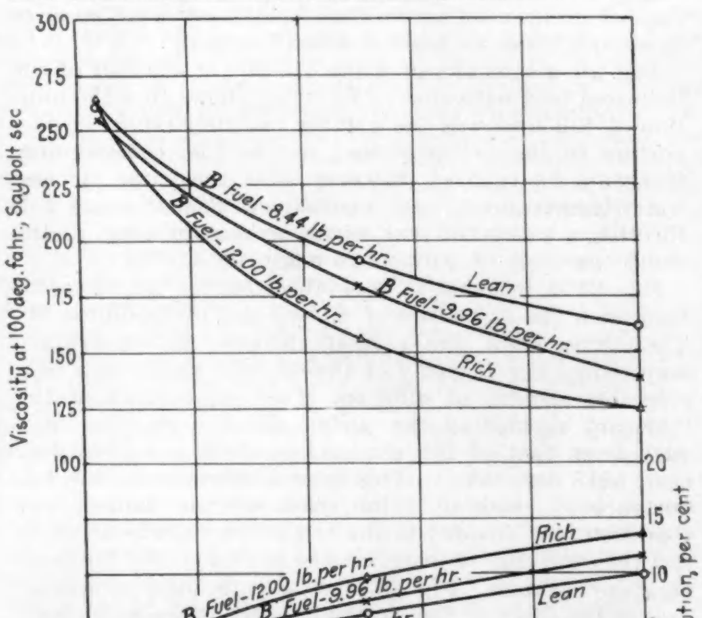

FIG. 25—EFFECT OF MIXTURE-RATIO UPON THE RATE OF DILUTION WITH *B* FUEL

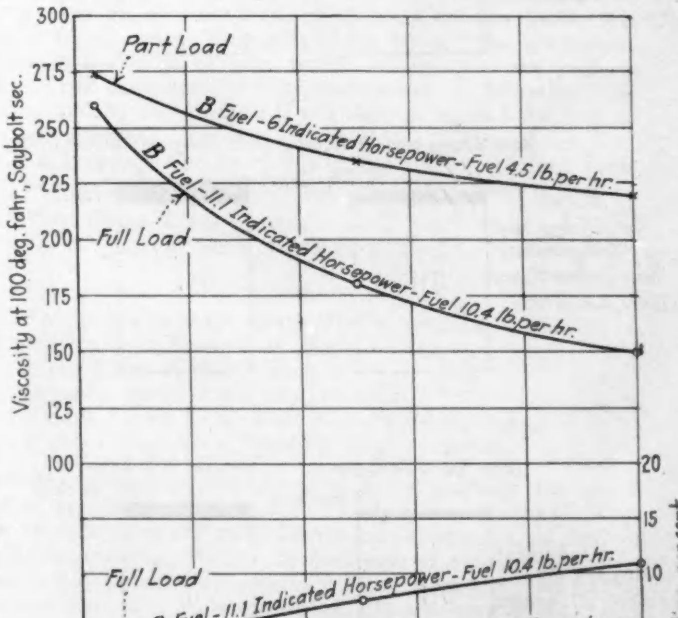

FIG. 26—EFFECT OF LOAD UPON THE RATE OF DILUTION WITH *B* FUEL

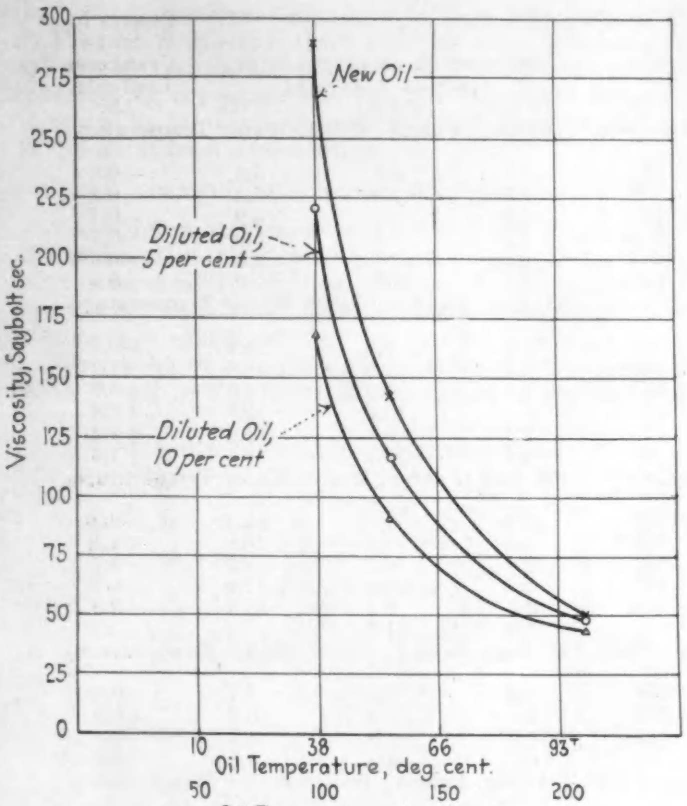

FIG. 27—VARIATION IN THE VISCOSITIES OF NEW AND DILUTED OILS WITH THE TEMPERATURE

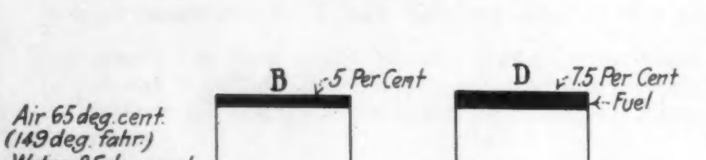

FIG. 28—CHART ILLUSTRATING THE RELATIVE MAGNITUDE OF THE EFFECT OF FUEL VOLATILITY, CIRCULATING-WATER TEMPERATURE AND MIXTURE-RATIO UPON DILUTION

A probable explanation of why the water temperature is the predominating influence is as follows: The highest carbureter-air temperature used, 65 deg. cent. (149 deg. fahr.), probably is not high enough to vaporize all of either fuel, even if there were sufficient time. There is always liquid fuel entering the cylinders at both high and low air-temperatures but, of course, there is a greater proportion of liquid in the latter case, the increase being in the more-volatile portions. The more-volatile portions of the liquid vaporize readily enough in the cylinder and only the less-volatile portions contribute to the dilution. Therefore the greater amount of the lighter constituents entering the cylinders as liquid at the lower air-temperatures makes little difference. The least volatile fractions are not vaporized at the time of entrance with either of the carbureter-air temperatures considered and, hence, become the determining factor. The rate of dilution depends therefore upon the ability of the piston and the cylinder wall to vaporize the heaviest portion of the fuel, which is a function of the jacket-water temperature.

Figs. 24 and 25 serve to illustrate the effect of mixture-ratio upon dilution. It will be seen that the richer the mixture is, the greater the dilution will be, and that the effect is approximately in proportion to the rate of fuel consumption.

The results of the 15-hr. dilution test given in Table 5 show that the viscosity decreases rapidly throughout the test. This seems to indicate that, with low temperature-conditions, dilution does not reach equilibrium in a test of this length. The Saybolt viscosity of the lubricant at 37.8 deg. cent. (100 deg. fahr.) was reduced to less than one-third that of the unused oil. A contemplated 15-hr. test with higher air and water-temperatures may show a considerably different result. At the higher oil-temperatures such as will be obtained, the diluent may be distilled from the lubricant at such a rate as ultimately to equal the rate at which the fuel was being added and equilibrium ensue. The relative ability of two fuels to reach equilibrium while the oil still has sufficient lubricating qualities may be an important consideration in any oil-consumption estimates as between two fuels. The rate of dilution under starting conditions was found to be several times as great as when operating.

Fig. 26, a comparison of the dilution at one-half of the indicated load with that at full load, shows that the dilution at full load was the greater and apparently in proportion to the indicated load or the fuel consumption. It should be realized, however, that the same air and water-temperatures were maintained at part as at full throttle, a condition that rarely exists for long in the usual operation of automobile engines.

Fig. 27 is included to show the effect of the temperature upon the viscosities of diluted and of undiluted oil. The curves show that a small increase in temperature may reduce the viscosity of the oil fully as far as a considerable amount of dilution. The temperature of the lubricant separating the piston and the cylinder may vary from that of the atmosphere to at least 100 deg. cent. (212 deg. fahr.). This is an illustration of the importance of choosing a lubricant for the temperature condition best adapted to the engine under consideration and then striving to maintain the lubricant and the temperature constant. Fig. 28 illustrates the relative magnitude of the effect of fuel volatility, circulating-water temperature and mixture-ratio upon dilution.

CONCLUSIONS DRAWN FROM CRANKCASE-DILUTION TESTS

In conclusion, the rate of crankcase dilution is greater with the less-volatile fuels under all conditions of test.

In that these conditions cover a wide variation of mixture-ratio and of air and water-temperature, it is reasonable to suppose that such would be the case during a large majority of the time of operation of existing cars. That many cars have engines differing from the test engine in design may alter the magnitude of the differences but not the fact of their existence. In general, it has been found that the circulating-water temperature has the greatest single influence upon the rate of dilution, and that the mixture-ratio has a considerable effect.

Acceleration and Starting Tests

The acceleration and starting tests are now being run with the Car-*Z* engine set-up. It is hoped that the methods used will detect any significant differences which may exist.

MOTOR-TRANSPORT ACTIVITIES OF THE OFFICERS' RESERVE CORPS

As the National Defense Act forms our military establishment into a small standing army and a large reserve, it is desirable that those engaged in the automotive industry interest themselves as citizens and tax-payers in the development of this Reserve. The mistakes made during the war are well known to those who served in the ranks, as well as to those who managed the many different organizations that were directly or indirectly engaged in furnishing munitions of war, whether it was cotton for the tents, steel for the ordnance or automotive parts for transportation, and to prevent, if possible, and in any case reduce the number of the mistakes that occurred in the past, officers in charge of the various Corps Areas are making every effort to interest men who would, in time of war, be called into active service, especially technical and mechanical men.

It is recognized that able-bodied men will be drafted into the service with or without their consent if the emergency requires it. The problem is to anticipate the demand. A bulletin describing the regulations for the Officers' Reserve Corps may be obtained from the Army. One having determined which branch of the service he wishes to enter, it is necessary to have the application papers forwarded to the Commanding Officers of a Corps Area for a commission in the Corps. Each organized reserve unit will be localized, with all its officers residing in its own territory. The enlisted personnel will be assigned to units localized in or near their places of residence. Provision will be made for transferring the officers and the enlisted men, upon any change of residence, to similar units in their new homes.

As the reserve will be distinctly a war force and will not be called to the colors except in such an emergency, it will attract a class of citizens who do not feel inclined or are unable to undertake the obligations assumed by members of the National Guard. Moreover, the reserve will be maintained as a skeletonized force and will not compete with the National Guard. The policy of the General Staff contemplates a well-balanced force officered by regular, National Guard and organized reserve officers and capable of expansion to any required size. The expansion of the limit of strength will take place through voluntary enlistment or draft as emergency may demand. Each Corps Area will contain troops from the regular army, the National Guard and the organized reserve; all organized in time of peace into brigades, divisions and Army corps, with the necessary auxiliary and special troops.

By joining the Reserve Corps one becomes a part of an organization that is being developed to save time and money and to reduce the expense of maintaining a war-time organization. During the war many "misfits" were placed in charge of departments because no preparation had been made for motor transportation. The present plan is to eliminate confusion and to assign in each locality an organization recruited so far as possible from ex-service men and whenever it can be done to retain their World War designation. These men will be formed into a skeletonized organization, with a commanding officer and the necessary aides. As the organizations fill up, motor repairmen of various degrees of skill will be assigned. There will be no demands on one's time other than to sign the necessary papers for joining, undergo a physical examination, and if one is anxious to progress in the Service to take up the Army Correspondence Course that endeavors to teach potential soldiers the rudiments of the Service.

Local pride will be involved in the formation of any given organization. It will retain its identity in skeletonized form throughout the period of service. A certain motor-repair battalion is now attached to the First Army, with its commanding officer and his adjutants, the Headquarters Organization, Companies A, B, C and D with their captains and lieutenants; even the medical and dental officers have been assigned to this organization. In case of war the officers, who have become acquainted with their commander, their associate officers and their assistants will be ordered to mobilize. There will be little confusion in terminating one's affairs and gathering at the various contact points.

The terrific change that emergencies of this kind entail upon everybody is well known and there is no question about the advisability of preparing now for the war that may or may not come, and as we have been more or less active in criticising the lack of forethought on the part of those responsible for our preparedness or lack of it, it is our duty to stand back of this movement and interest ourselves and our neighbors in joining this organization that costs the individual little or nothing and entails no additional expense upon the Government. We must organize, preferably with the men who have seen some service. However, any man of fair education and some executive ability should be able to pass the examination and obtain a commission in this reserve force, and as time goes on fit himself for promotion. No doubt hundreds of men would be glad to take part in this reserve movement, if they understood the situation. As citizens and as engineers it is our duty to spread the idea as far as possible.

Full details of the Reserve Corps may be obtained from the various Corps Area Headquarters listed below:

First Corps Area, Boston.
Second Corps Area, Governors Island, New York Harbor.
Third Corps Area, Baltimore.
Fourth Corps Area, Fort McPherson, Ga.
Fifth Corps Area, Fort Hayes, Ohio.
Sixth Corps Area, Chicago.
Seventh Corps Area, Omaha, Neb.
Eighth Corps Area, Fort Sam Houston, Texas.
Ninth Corps Area, Presidio, San Francisco.

While the automotive industry is particularly interested in this movement, the chemist can join the Chemical Warfare Branch; and the metallurgist, the Ordnance, as well as the Quartermaster Corps. In fact men of any trade or profession may enter this reserve, knowing that their particular qualifications will be appreciated. Prospective officers may be accepted without examination prior to Nov. 1, 1923, upon stating their previous experience. Other applicants will forward with their applications a record of their civil experiences, as the intention of the War Department is to have each man in the position best suited to his particular ability or talent.

Aircraft-Engine Practice as Applied to Air-Cooled Passenger-Car Engines

By S. D. Heron[1]

Annual Meeting Paper *Illustrated with* Photograph

THE discussion of Mr. Heron's paper, presented at the 1923 Annual meeting, includes written contributions and the remarks made at the meeting. For the convenience of the members, an abstract of the paper is printed herewith, together with a reference to the issue of The Journal in which the paper appeared, so that members who desire to refer to the complete text as originally printed, and to the illustrations that appeared in connection therewith, can do so readily.

ABSTRACT

STATING that most of the copying of aircraft practice in post-war car-design has proved a failure because the fundamental difference in duty has not been realized, the author proposes to show wherein the automobile designer and the engine builder can profit by the use of practice developed for air-cooled aircraft engines and, after generalizing on the main considerations involved, discourses on the simplicity of layout of the efficient air-cooled cylinder as a preface to a somewhat detailed discussion regarding cylinder design and performance, inclusive of valve location, type of finning and form of cylinder-head.

Cylinder material, cooling surface, port arrangement for in-line engines, and the camshaft and valve-gear arrangement most desirable are subjects treated at length and illustrated, the thought then passing to a consideration of sleeve-valve types, temperature and exhaust-valve cooling, in such detail as to include many enlightening data; and similar treatment is accorded the subjects of air supply, a cooling system for in-line engines, air-blast direction and the necessary quantity of air. Desirable types of fan, spark-plug, piston and fuel are commented upon somewhat briefly. The author concludes (*a*) that scaling-down of design in internal-combustion-engine cylinders is a safe process, while scaling-up is decidedly unsound; (*b*) that, since thermal troubles have been the greatest cause of difficulty with air-cooled cars, a consideration of the designs capable of continuous full-throttle operation is likely to demonstrate the ease with which the relatively mild thermal difficulties of an air-cooled car can be overcome.

Appendix 1, by C. Fayette Taylor, treats the subject of the experimental development of air-cooled engine-cylinders specifically; it reviews briefly the methods used by the Engineering Division in developing and testing cylinder units for both air and water-cooled engines, and discusses some of the results obtained with several of the air-cooled cylinders mentioned in the paper proper. Performance investigations of experimental cylinders are described and commented upon, inclusive of illustrations and tabular data that are given rather lengthy attention. Laboratory experience in regard to exhaust-valve cooling is related, together with mention of the experimental results with internally cooled valves. Subsequently, many air and water-cooled-type comparisons are made, the conclusion being that there will be a rapid and healthy growth of the air-cooled type of powerplant for automotive vehicles.

Appendix 2, by E. H. Dix, Jr., has as its subject the foundry production of air-cooled cylinders with the fins cast integrally and first describes the experience of the Engineering Division foundry in casting aluminum-alloy cylinder-heads, numerous illustrations of castings being included. The suitable gating for aluminum-alloy casting is discussed, supplementary illustrations being presented, and the conclusion is reached that the experience related tends to show that air-cooled cylinder-head castings of the types illustrated are far from being bad production propositions.—[Printed in the January, 1923, issue of The Journal.]

THE DISCUSSION

L. H. Pomeroy:—My experience with automotive engines generally is that no small amount of the difficulty in maintaining silence of working and general freedom from erratic behavior is related to temperature variation. It seems to me that any development that increases the temperature range in an engine is to be regarded with suspicion. There is, of course, ample evidence that air-cooled engines are reliable mechanically, but the buying public demands silence as a first condition. Furthermore, this question of temperature and its effect upon bearing clearance is intimately connected with what may be termed local vibrations such as those arising from loose wristpins, camshaft bearings, and the like. Even starting from cold seems to have its difficulties, although my experience of this is confined to one or two examples. Nevertheless, it is reasonable that the volume of water in a water-cooled system acts as a thermal-storage arrangement, preventing the engine from rapidly getting chilled to the bone so that the oil-films in every bearing become glutinous.

Mr. Heron apologizes for the high internal friction of the universal test-engine. Is there any difference between the air and the water-cooled cylinders in this respect? If the effect of air-cooling is to cause a greater vitiation of the qualities of the lubricant on the cylinder wall than is now the case, the effect on the mechanical efficiency at part throttle is a serious matter, particularly as it takes as much horsepower to drive the engine as it does to drive the car at speeds of the order of 20 m.p.h.

C. P. Grimes:—Mr. Heron has gone into many things that the automobile builder might not meet because he has not found it necessary to develop such high brake mean-effective pressures as Mr. Heron mentions. We feel that, whereas the circumferential fin might lower the temperature in its immediate vicinity, there is a considerable gain in having the fin parallel with the axis of the cylinder, much as we have shown it, as it assists greatly in carrying the heat from the head through the fin down to the lower parts of the cylinder, to be radiated better there, perhaps, than could be done if there were

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a single fin around the circumference at the head, or combustion-chamber, only, because the other fins could not communicate with that particular fin in taking away and dissipating the heat.

In following water-cooled practice very closely for 12 years, I have observed this: Supposing that the air-temperature were about 94 deg. fahr. and that the automobile were traveling on a level road with a water-cooled radiator, it would be found that the air passing through the water-cooled radiator would rise in temperature from 26 to 29 deg. fahr. while averaging from 25 to 50 m.p.h.; whereas, in our car, under the same conditions of load, pavement and air-temperature, the air would rise in temperature a little more than 80 deg. fahr. In other words, every cubic foot of air worked on in the air-cooled system would suffer a rise in temperature a little more than twice that in the water-cooled system.

I was pleased to hear that the Engineering Division has developed a fan that has an efficiency of 74 or 75 per cent. That is the first fan of that type with so high an efficiency that I have heard about. In my experience, the efficiency of a fan behind a radiator is decreased because the radiator and the engine are so close to the fan that the latter cannot work as it should. The result is that the air-efficiency of the fan is very low; whereas, in air-cooled practice, we place the fan in a scroll housing and have been able to get from 65 to 68 per cent actual efficiency in moving the air. The air-cooled engine has, of course, no water-pump. In our construction the fan is directly on the crankshaft and has no extra bearing-losses. The fan has an efficiency from two to three times that of the average fan behind the radiator.

Regardless of the cooling medium used, the average engine must dissipate a certain average amount of heat by way of its radiating system for any given average speed of operation. The direct air-cooling method allows us to raise the temperature of each cubic foot of air handled more than twice the amount possible when using a water-filled radiator-core and, at the same time, maintain a cooler cylinder-head. It also allows us to build our fan into a scroll and operate it at an efficiency of from two to three times that possible when using a blade fan close-up behind a cellular radiator. It avoids the power loss incident to a water-pump and, in our case, avoids the use of a belt drive with its inherent power loss, to say nothing of the expense and care of the additional fan bearing usually required. By careful measurement, our cooling fan was found to absorb less than 0.3 hp. at a car speed of 20 m.p.h.

The question of starting has been brought up by Mr. Pomeroy, who spoke about the engine's cooling-off rapidly as soon as it was stopped. I cannot see but what that speaks very favorably for the efficiency of the cooling system. Briefly, in our latest car we have an electric heater-coil in the carbureter in conjunction with a distinct and separate carbureter auxiliary to the main instrument. If a button on the dashboard is pushed, this will raise a valve from the auxiliary carbureter to the main yoke passage. It will allow 80 amp. of current to flow through a heating-coil, one end of which is submerged in gasoline, the whole coil being insulated from the carbureter by a porcelain tube. At 20 deg. below zero, fahr., at which temperature I remember having seen these tests conducted, it was necessary to push the button for 40 sec. This allowed 80 amp. of current to flow through the heating-coil, which developed a red heat, and transformed the liquid fuel that, in this case, was very nearly kerosene, the ordinary fuel purchased at a filling station, into what looked to me to be a kind of gray fixed-gas. It did not seem to condense on metal of any kind and seemed to flow up through the suction yoke. Forty seconds was sufficient time to heat up the chamber and to produce a sufficient volume of gas to fill entirely the suction yoke of the engine. The next operation in starting was to push the starting-switch, as always is done, and draw 400 amp. of current, as is the case with any engine of similar size. After the engine had been turned-over for not to exceed 5 sec., to get a charge into the cylinder, it started. If desired, the engine would continue to run on this small auxiliary carbureter, at a road speed of 18 m.p.h., and with a five-passenger load, for a week.

I wish especially to call attention to the fact that, whereas we were using 80 amp. of current for 40 sec., this is far less than the 400 to 450 amp. that would be required to crank the engine; in other words, we used not to exceed one-third the energy from the storage-battery that is customary on many other cars. After this primer has produced the fixed gas and has allowed the spark-plugs to work upon a combustible mixture and to start, the entire exhaust of the engine is passed through a cast aluminum vaporizing heater that is located directly above the carbureter. This heater, when a room-temperature of 84 deg. fahr. prevails, transforms the gasoline and the air into a dry condition, with a temperature of 160 deg. fahr. $\pm$ 5 deg. fahr., throughout the entire range of the engine, with the throttle either wide-open or in ordinary running position, excepting that at 15 m.p.h. and less it is slightly cool. If a draft of air on the crankcase is provided, to maintain the oil at a reasonable temperature, this powerplant can be used at 100 to 110 deg. fahr. in the shade, if desired, for sawing wood or pumping water all day, without need of worry about the cooling or the heat effects on the engine.

H. S. McDEWELL:—Although I have a more or less open mind on the subject of air and water-cooled engines, it is impressed upon me that, if the same quality of research brain-power and quantity of research endeavor had been put into the problem of water-cooling as have been put into the problem of air-cooling, the resulting water-cooled engine would differ as much from its present type as does the present-day high-duty air-cooled engine from the original attempts with this latter method of cooling. It is my impression, an impression that I think is thoroughly justified, that such work as has been done in investigating the cooling of the water-cooled engine has been of a decidedly haphazard nature. I feel, therefore, that there is a vast field for improvement in water-cooling, and that some of the handicaps and limitations that have been placed on it by the work of Mr. Heron and his associates, both in this Country and in England, should be overcome.

With regard to the so-called grafting of aircraft practice on post-war cars, it would seem, particularly with the cars in which such practice is advertised, that the engineers and the designers responsible have failed to keep in sufficiently close touch with actual aircraft design and development to be able to approach good aircraft practice even relatively, and it is to this fact that failure has been due. In some cases actual aircraft practice has been used, but not advertised. In these cases, the results have been entirely satisfactory. Successful aircraft practice is nothing but good design and, therefore, if incorporated into any machine, it must be successful provided the service conditions are not such as to prohibit its use. The fact that tests of the single-cylinder engine apparently cannot be approached exactly in the multi-cylinder engine does not, in my opinion,

vitiate the results. Experimental work can be carried on much more rapidly and cheaply on a single-cylinder engine than on a multi-cylinder type and, while it is not to be expected that the single-cylinder-engine results can be duplicated on the multi-cylinder engine, the single-cylinder at least provides a mark at which to shoot in multi-cylinder work.

With regard to the life of valves, particularly the exhaust-valves in high-duty aircraft-engines, it may be well to state that not only 100 hr. of running without overhauling, but 300 hr. without attention to the valves, has been attained on more than one occasion on service engines, with silchrome valves.

With regard to exhaust-valve cooling, it is entirely possible to use a valve with a thin seat and still get the necessary cooling. Sometimes the thin seat may be necessary in adapting a valve to an engine in which the cooling around the seat has not been attended to properly. In a case of this kind, the problem is purely one of conducting the heat up to the stem, and this has been done successfully by using a tulip valve, but considerable attention must be paid to the design of the valve. Care must be taken that the sections are not so weak that the valve will fail from fatigue. If the section at a slight distance from the seat be too weak, cracking will occur there; but, by a silght thickening, trouble can be averted. The valve so resulting will have a spring action lacking in the stiffened valve described by Mr. Heron, and a tendency to cut the carbon from the valve-seat and keep the valve in good condition. Valves of this kind will withstand long service without attention and, when used to replace a flat valve or a valve with a slightly domed head, will run at a temperature in the vicinity of 900 deg. fahr., instead of 1300 deg. fahr., as in the case of the flat-head valve. Such valves, on account of their tulip form, produce approximately a 5 per cent increase of power, so that the reduction in temperature is not due to reducing the heat going to the valve. What compression-ratio and fuel did Mr. Heron use to obtain the results stated under "Form of Cylinder-Head" on p. 33 of his paper?

Referring to the thick section of metal necessary for a cast-iron head, as against the old opinion that for heat flow the section must be thin, the former is, of course, supported by theory, if the theory is predicated properly. Heat must not only be transmitted through the combustion-chamber walls, but must be transmitted along the metal sufficiently to give an ample area to dispose of it on the outside of the cylinder without an excessive temperature. To just what feature of the design does Mr. Heron ascribe the successful results obtained with the cast-iron type-K cylinder, since he states that very satisfactory operation was obtained in spite of very high wall-temperatures? It is my understanding of the text that better results were obtained with the cast-iron than the aluminum type-K cylinder. Is this correct? Is an engine of the B. S. A. type, without a fan, able to maintain its cooling under constant or long-sustained low-gear operation, such as that of climbing over Pennsylvania hills?

With regard to breathing through the valve-gear, I suggest that the length of the valve-gear itself provides a sufficiently long breather passage to cool the oil vapor. Consequently, if the engine is dirty as a result of locating the breather in that position, the trouble is due to velocity; the opening to the air is not sufficiently large or is possibly insufficiently baffled and attention to this point will obviate dirtiness.

With reference to the application of the sleeve valve to air-cooled engines, the trouble might possibly be caused by the fact that the heat transmitted from the piston skirt and rings to the cylinder wall by way of the sleeve or sleeves would be much less than in the case of direct transmission, such as occurs in a normal type of engine.

I cannot help feeling that Mr. Heron has neglected oil-cooling in his paper. He has talked entirely about air-cooled-cylinders and has altogether neglected to state that the average air-cooled engine, and water-cooled engine too, for that matter is to a large extent oil-cooled. He does not state whether, when he used the internally cooled valve, he depended on oil for the external abstraction of the heat from the valve. It has been my experience that when an attempt is made to direct the flow of air, as is necessary with circumferential fins, particularly when the air is stirred-up by a propeller-type fan, the baffling required is not as simple as it appears at first sight; in fact, it is a difficult matter requiring considerable time and experiment.

At the present state of the art, I hardly think that an exhaust turbine-driven fan is a commercial possibility. My impression has been that, at McCook Field, it has been a case of about 1 hr. of flight and 24 hr. of overhauling of the turbine-driven unit, although such conditions may have been improved since I was familiar with them.

I wish to commend Mr. Heron on his statement of views with regard to the inadvisability of scaling-up designs and the entire safety of scaling them down. Starting with large dimensions is much more apt to cause trouble than starting with small dimensions. If, with a large-dimension design, it is possible to overcome all troubles, the inference is that when an attempt is made to build smaller engines of the same relative design, the troubles overcome in the large design will not be encountered.

THOMAS MIDGLEY, JR.:—There is not much that I can add to what most of you have already seen. The copper-cooling development is a perfectly obvious thing. The substitution of copper for cast-iron is due to the fact that copper is the better conductor of heat; with the same disposition of material an engine is cooled better by using copper than by using a ferrous metal. The development of the copper-cooled car was not so much the development of a cooling system as it was the development of a car. We felt that we had a good engine and we wanted a good car to put it in.

MR. GRIMES:—What is the method of putting the copper on cast-iron cylinders? What are the temperatures of the air coming from the fins, and the operating temperatures of the head, or of the walls of the cylinder, under either level-road or full-power conditions?

MR. MIDGLEY:—We take a well-finished cast-iron cylinder and then braze on the copper fins. A research problem was involved in handling the brazing operation, as well as some technical details that had to be mastered. I do not know the actual temperature of the air leaving the fins, but it is about 100 deg. cent. (212 deg. fahr.) above normal room-temperature. The temperature in our engine with a wide-open throttle does not compare unfavorably with the temperature that exists in a water-cooled cylinder under the same conditions.

MR. POMEROY:—Does that depend on the fact that the cylinders were small in dimensions? Would the same reasoning hold for a larger cylinder?

MR. MIDGLEY:—Yes. We have run break-down tests on our engines. We get the same brake mean-effective pressure and the engine is just as good. After several thousand miles of operation, a water-cooled engine, as

compared with a copper-cooled or air-cooled engine, has lime, calcium salts and all sorts of impurities in it, for the water found around the United States is not water, but a salt solution. About 1-16 in. is left on the outside of the cylinder, inside the water-jacket, and what good does it do to put the water around it after that? Many cars are sold for the third and fourth time, not because the bearings have become loose, but because there is about 1-16 in. of lime outside of the cyinder, and then the engine runs roughly as a result. If you could get the lime out, you would again have a fair operating mechanism. The copper-cooled engine runs at approximately the same temperatures as a water-cooled engine under the same conditions. The hot gas inside the cylinder does not know in what way it is being cooled on the outside; it merely knows how well it is being cooled.

C. L. LAWRANCE:—There is expansion in the cylinders of air-cooled engines, causing greater valve clearances when hot, but there is also expansion in the cylinders of water-cooled engines that have the standard overhead-valve and push-rod and increased clearance. Nevertheless, many first-class cars are built with this method of valve operation. If there is trouble from the enlarged clearance due to such expansion, it is possible to regulate the clearance so that it will stay practically the same at all cylinder temperatures. With properly designed pistons, I cannot see that there should be any more noise from a properly designed air-cooled engine than from a water-cooled engine.

It has been said that there is an unusually high frictional resistance in a single-cylinder air-cooled engine. This is equally true of water-cooled, single-cylinder testing engines. I believe that they do not differ in any respect; in fact, there is very little frictional resistance in some air-cooled engines. I know of one engine tested at McCook Field that showed a mechanical efficiency of 92 per cent.

Mr. Grimes has said that the high mean-effective pressures mentioned by Mr. Heron are not required. That is true. As high mean-effective pressures are not required, the extreme cooling required in aircraft practice also is not necessary, but it seems to me that it is desirable to remove the heat from the place nearest to the point at which it is produced, the combustion-chamber. Why is it not logical to cool the top and sides of the combustion-chamber, and not merely the sides and barrel of the cylinder? If that were done, it would be possible, probably, to have less cooling medium and a slower flow of air and, perhaps, to use less power in the blower.

In water-cooled engines, it is usual to cool the cylinder-head. It seems to me that the greatest tribute to air-cooling is the fact that engines can run satisfactorily with practically no cylinder-head cooling. With proper study of the conditions of the head, air-cooled engines for motor cars can be made to cool in the same sizes as engines with practically no cooling except the very smallest flow of air over the head.

C. B. DICKSEE:—There are many advantages to be claimed for longitudinal fins, chiefly because all the cooling air passes directly where it is most needed, over the cylinder-head, particularly if the direction of airflow is that adopted by two builders of air-cooled cars, in which the cold air strikes directly on the hottest part of the engine.

There is no reason why there should be any doubt about the kind of junction between the steel fin and the iron barrel with cast-in steel fins. Our firm builds small engines that use this type of cylinder. When cylinders have been cut-up, we have found that the weld between the fin and the iron barrel is perfect. These cylinders require care and attention in the foundry, but are produced readily at a low cost. When a nail or some light steel instrument is run round on the fins, they will ring like a bell if tight; if they are not tight, they will jangle. Whenever we have cut-up a cylinder that has rung true, it has invariably been found to have a perfect weld.

The microphotograph, Fig. 38, shows that the weld we obtain is perfect. The white part, which is the fin, tapers off to a point. That is because the steel has actually been washed away by the iron in producing the weld; about 50 per cent of the steel that was inserted into the iron has actually been fused away. Fins are not all fused

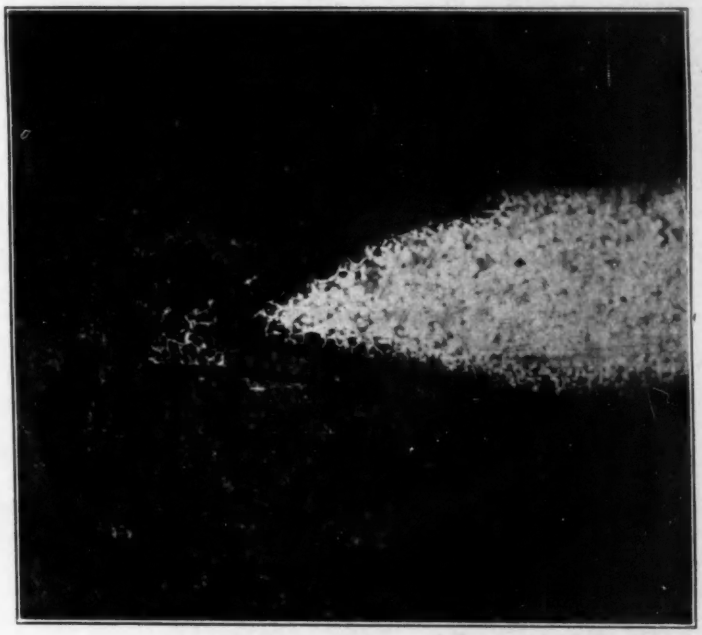

FIG. 38—MICROPHOTHGRAPH OF THE JOINT BETWEEN AN IRON AIRCRAFT-ENGINE CYLINDER AND THE STEEL RADIATING FIN THAT WAS WELDED IN PLACE

away to the same extent, but there is invariably a certain amount of washing away and perfect adhesion in almost every case. We get scarcely any cylinders now that fail to ring true.

With reference to cleaning the cylinders, where the ends of the fins are turned over there is possibly some difficulty in cleaning the ducts of longitudinal fins, but compressed air will clean them as readily as it will clean circumferential fins, whereas a piece of stovepipe put on over the fins is easily slipped off and the duct cleaned out with a brush. I have found that a considerable amount of filth has very little effect on the cooling. The air in the neighborhood in which our plant is located is particularly dirty and engines that have been run for protracted periods, some of them more than 2000 hr. on full load, have been found to have the cooler parts of the cylinder completely covered with fluff and filth, but the engines worked perfectly under those conditions. Where the temperature is high enough to dry off oil, the dirt will not stick.

Referring to Mr. Heron's statements as to the pressure loss with longitudinal fins, we have measured the loss of air pressure through the ducts and have found the chief loss to be an entry loss; that is, most of the air pressure is used in accelerating the air from the slow stream approaching the cylinder to the rapid stream

through the duct. This would be true whether the cylinder has circumferential or longitudinal fins. The actual loss in the duct itself is very small.

What does Mr. Heron consider to be a satisfactory working temperature of the cylinder-wall? He has mentioned cylinder-head temperatures, but the cylinder-wall temperature affects lubrication. On our machines we have found that the temperature at the top end can rise to about 110 deg. cent. (230 deg. fahr.) without causing trouble. Ordinarily, the mean cylinder-wall temperatures of an engine running at maximum load will vary from 180 deg. cent. (356 deg. fahr.) at the top, to 150 deg. cent. (302 deg. fahr.) at the bottom.

To test the engine's ability to start in cold weather, we took one of our machines to a refrigerating plant and froze it up overnight to 20 deg. below zero fahr. Using the gasoline that had been in that temperature all night, the engine started on the second cycle of cranking. The piston clearance is 0.002 in. A water-cooled engine under those conditions would have had to have its radiator drained overnight and would be as cold as an air-cooled engine. It seems to me, therefore, that the question of starting is the same for both machines. Once an air-cooled engine has started it warms-up very rapidly; whereas, in cold weather, a water-cooled engine sputters for a considerable period. The trouble with the starting-motors is, I think, due to the fact that most air-cooled-car builders up to the present have used a double-purpose machine that has to be wound to act both as a starting-motor and as a lighting generator, and produce the necessary torque at low speeds. Consequently, it is considerably larger than a standard machine.

C. A. NEVINS:—How is the head of the copper-cooled cylinder cooled? I noticed there is no finning.

MR. MIDGLEY:—Heat flows from the head to the fins at the side of the cylinder.

MR. NEVINS:—What insulating material is used between the manifold and the head of the cylinder? Is it copper and asbestos?

MR. MIDGLEY:—Yes.

A. M. WOLF:—Is it possible to maintain the alignment of the valve-stem, which is in a separate casting, with the valve-seat that is in the cylinder-head, especially after the engine has been taken-down several times? Inasmuch as the gasket is inserted between these two points, any variation in the thickness seemingly would spoil the alignment.

MR. MIDGLEY:—This gives no trouble. There should be no occasion to remove the superstructure from the cylinder. After having driven several cars thousands of miles, we have had no trouble.

DR. H. C. DICKINSON:—A subject that has been exercising persons interested in fuel is the uniformity of the cylinder temperature. In fact, some of our members have become interested in steam-cooling systems for the sake of maintaining a uniformly high temperature in the cylinder-walls. Has someone anything to say on the subject of the maintenance of a uniform cylinder-temperature; that is, uniformity as regards time, with air-cooled cylinders?

MR. GRIMES:—Formerly, we felt that the high temperature of the air-cooled engine was a big factor in the economy of operation of the car; but recently research work has convinced us that the temperature of the cylinder is not related to the economy of the engine in any way. Of course, we know that if we packed it in cracked ice it probably would not work as well as if it were warmed-up.

At 20 m.p.h. under temperature conditions of 90 deg. fahr. in the shade, the cylinder-head is the hottest point, except the exhaust-valve itself, and reaches a temperature of about 190 deg. fahr. By choking-off the air-cooling, I have raised the temperature to 450 deg. fahr. I have operated the engine at 650 deg. fahr. A temperature of 660 deg. fahr. melted a hole in the piston. When operating normally at 110 deg. fahr. in the shade, the cylinder-head temperature does not exceed 400 or 425 deg. fahr.

We made a series of economy runs at 20 m.p.h., with a cylinder-head temperature of 190 deg. fahr. When we raised that temperature to 425 deg. fahr., the average of five runs showed that there was a difference in the economy, or miles per hour, of not to exceed 1 per cent. That was not brought about solely by the cylinder-temperature. If we did not have the exhaust-heated vaporizer that really converts the carbureted gases into a dry and more or less perfect vapor, the cylinder-head temperature would control the economy; but, since we feed to the cylinders a gas that is dry, or practically so, at a temperature around 150 deg. fahr., the cylinder-head temperature is no longer a factor in economy.

S. D. HERON:—High brake mean-effective pressure, high output and large cylinders were stressed in the paper to show the relative ease with which an air-cooled car-engine can be cooled. If it is possible to produce cylinders with an output of 40 to 50 hp. per cylinder that will run on full throttle for 8 hr. per day without cooling or other trouble, there should be no difficulty in producing an efficiently cooled automobile engine. In this connection, it is well to consider that a 240-cu. in. capacity automobile-engine will run most of its time with an output of less than 10 hp., whereas an aircraft engine of similar capacity must be capable of delivering about 70 hp. at a speed of about 1800 r.p.m. continuously.

Cooling is really the least of the difficulties with an air-cooled car-engine; this point should really give no trouble at all. Silence is likely to be the most troublesome feature. The problem of silence has been very satisfactorily solved in at least one air-cooled car now on the market, but it is likely that attempts to produce air-cooled car-engines capable of continuous high speed, say 60 m.p.h. and more with engine capacities of 200 cu. in. or less, may necessitate the development of much new-design technique to secure such performance with real engine-silence. If an air-cooled car-engine with the quality of extreme silence of operation is required, the sleeve-valve type is well worthy of consideration, and I think that there is little doubt that this type of engine can be air-cooled successfully.

When Mr. Pomeroy speaks of raising the temperature of the mass of material around the bearings by 200 deg. fahr., I can only assume that he is exercising his sense of humor. That he should believe that the bearing temperatures in air-cooled engines of decent design are 200 deg. fahr. higher than in water-cooled engines does not seem possible, any more than it would seem possible for bearings working under such a handicap to function for anything but a very limited period. Mr. Pomeroy jibes at the starting qualities of air-cooled engines, while knowing full well, of course, that the cooling system has little or nothing to do with the starting of an engine. The starting of air-cooled engines at McCook Field is at least as certain as that of the water-cooled types. In most cases, air-cooled aircraft-engines are started by priming, swinging the propeller for a few revolutions and using the booster magneto with the crankshaft at rest. Even with an air temperature of 10 deg. fahr., a start is generally obtained at the third or fourth attempt. It would

be of interest to know how many water-cooled car-engines would respond to such starting methods with an air temperature of 10 deg. fahr.

While apologies are due for the high internal friction of the universal test-engine used at McCook Field, and this is true of most single-cylinder test-engines, it may be well to notice that the apology is equally due whether the cylinder under test is air or water-cooled. Reference to Table 2 in the paper clearly illustrates this point. The friction mean-effective pressure of radial air-cooled engines has in general proved to be less than 15 lb. per sq. in., which is at least as low as that of most water-cooled car engines. That we are dealing with very high internal temperatures in air-cooled engines is very much open to doubt. The tests detailed in Table 4 of the paper show that a Liberty cylinder with 0.025 in. of scale on the walls runs about as hot as an air-cooled cylinder of equal output. It is not unusual to find 3-16 in. of scale in a water-cooled engine of aircraft type, to say nothing of what is likely in badly cooled water-cooled car-engines; thus the wall temperatures attained under such conditions are likely to be at least as high as in air-cooled engines.

CHAIRMAN T. J. LITLE, JR.:—What about the radiator?

MR. HERON:—On the Mexican border considerable trouble is experienced with scale in aircraft radiators. I have heard of cases where replacement was necessary after only 3 weeks of service.

My remarks on axial-fin cylinders were made to point out that there are other methods of designing air-cooled engines. Mr. Grimes and other speakers have referred to the advantages of the axial-fin type of cylinder, claiming among them that (*a*) the heat is conducted across the head to the fins on the barrel, and there is dissipated; (*b*) the axial fin conducts the heat down the barrel to the lower end, tending to equalize the temperature distribution; and (*c*) the cold cooling air is directed on the point where it is most needed.

Regarding claim (*a*), this is admitting that no attempt is made to dissipate the heat at the point where it is received by the wall. There is no question that the most efficient cooling is obtained in any engine, whether air or water-cooled, if the heat given to the walls is dissipated almost entirely at the point of reception. The circumferentially finned aircraft-engine type of air-cooled cylinder with the crown of the head, the valve-seats and the ports thoroughly finned, and with free access of air to all the fin cells, approaches the condition of heat dissipation at the point of reception much more closely than any axial-fin type yet seen. With an aircraft type of cylinder, removal of the fins from the barrel has very little effect on performance, but the result is very different if the barrel finning is left and the head finning removed, disastrous overheating being the immediate result.

CHAIRMAN LITLE:—That is because the engine is running wide-open. That would not necessarily apply to a passenger car.

MR. HERON:—No. On the other hand, by using highly efficient cooling methods, much less air is required; this results in an engine that warms-up quickly and has a low friction loss. When the power required to propel a car at 25 m.p.h. is considered, the percentage of the indicated power normally wasted in engine friction alone is appalling.

Regarding claim (*b*), the axial conduction of heat down the cylinder barrel in circumferential-fin-type cylinders is achieved readily by the use of a thick-section barrel. This would seem to be a more certain method of securing axial heat-flow than by conducting the heat from the barrel across the doubtful thermal joint of a cast-in piece, to the fin, and thence down the fin to the base of the barrel. Claim (*c*) is really rather amusing in view of the fact that most users of axial finning practically ignore the need for head cooling by either omitting head finning entirely or using such a fin layout that the cooling air practically is prevented from penetrating to the hot surfaces most requiring it.

A parallel to the cooling conditions of the average flat-head axial-fin cylinder would be produced by a water-cooled engine without water around the valve-seats, the guides and the ports. Much of the valve trouble in water-cooled car-engines today is due to a partial existence of this state. The designers who have spoken of the advantages of axial-fin cylinders have based their claims on experience of small-capacity low-duty cylinders. In this connection, it is worthy of note that no successful large high-duty axial-fin cylinder has yet been produced. That the axial-fin cylinder works in the sizes in which it has been produced is no proof of its soundness. If the advocates of this form of construction would submit their faith to the test by attempting to produce a 6-in.-bore axial-fin cylinder, they probably would obtain a very thorough knowledge of the advantages of scaling-up in showing-up the fundamental soundness or unsoundness of types of design in internal-combustion-engine cylinders.

CHAIRMAN LITLE:—What about the relative advantages of the integral and the brazed-on fin?

MR. HERON:—The integral fin is decidedly a better production proposition than the attached fin, whether brazed-on or cast-in.

CHAIRMAN LITLE:—How about performance?

MR. HERON:—The limit in output with integral fins has yet to be reached. To date, it has been found possible with integral fins to secure all the cooling needed on any cylinder size tried yet.

That the cooling air in the car he represents has twice the temperature rise that occurs in a water-cooled car is claimed as an advantage by Mr. Grimes. Mr. Grimes states also that the heat-loss to the cooling-air is equal in air and in water-cooled engines. I do not know what the average heat dissipation per brake horsepower is in a water-cooled car-engine. Prof. E. H. Lockwood spoke of 50 to 70 B.t.u. per b.hp.

That an engine causes a large temperature-rise in the cooling-air is by no means an advantage, necessarily. It may mean merely that a large amount of heat is rejected to the cooling-air when it might more usefully be given out through the crankshaft. From Mr. Grimes' figures in his recent paper on Air-Cooling of Automotive Engines[2], it appears that the minimum heat-loss from the cylinder walls to the cooling-air in the engine he describes is 88 B.t.u. per b.hp., which is at least three times as great as it is in an air or water-cooled aircraft engine.

While standard service-type aircraft-engines will at times run 300 hr. in flight without overhauling of the exhaust-valves being necessary, it may be well to point out that such a test is much less severe than a 100-hr. full-throttle test on a single-cylinder engine. I agree with Mr. McDewell that excellent cooling can be obtained with tulip valves having thick rims; the thick rim is, however, as explained in the paper, a safeguard against local overheating if the valve should start to blow and, in any case, it has a tendency to reduce the temperature

[2] To be published in an early issue of THE JOURNAL.

differences around the circumference of the valve. Fracture of the rim of a tulip valve is a rare occurrence in my experience; in fact, I have heard of only one case, in addition to that quoted by Mr. McDewell, the fracture being due to loose valve-seat inserts and resulting in severe impact loads. I am glad to note the commendation of the tulip valve as against the flat-head or mushroom type. I understand that the Wright Aeronautical Corporation has reached conclusions similar to those of Mr. McDewell and the Navy as a result of very extensive comparative testing.

To the best of my knowledge, the use of the tulip valve in modern aircraft engines has grown mainly out of the work of the Royal Aircraft Establishment, although I machined a set of tulip valves for an early aircraft engine 13 years ago when I was an apprentice. The reasons that led the Royal Aircraft Establishment to adopt tulip valves may sound amusing at this date; while working with very hot-running air-cooled engines, it was found that flat-head exhaust-valves always assumed tulip form after a period of running. This led to the obvious conclusion that the tulip shape might well be adopted for the initial form of the valve. Neither greater gas-passing capacity or more efficient cooling relative to the mushroom type, now generally considered to be attributes of the tulip type, had any bearing on its adoption.

I think that an engine of the B. S. A. type, that is, without a fan, would not prove satisfactory under conditions of constant low-gear operation for many miles either through deep sand or on steep mountain grades. This design has given excellent results on climbs of 2 miles of 1 in 8 grade in low gear. Under these conditions, an excessive temperature-rise of the cylinder is prevented by heat storage and radiation; and the first factor, of course, is subject to a time limit. The cooling of this car and other British types lacking a fan is really surprising and demonstrates the capability of an air-cooled car-engine. The road conditions in this Country are, of course, very much more severe than in the United Kingdom, where the lengthy mountain grades and long stretches of deep mud and sand found in this Country are unknown. Nevertheless, my experience with the B.S.A. car would lead to the conclusion that the relatively large engine capacities required by the domestic market would, to a very large extent, balance the superior road conditions that these small-capacity two-cylinder fanless British-designs enjoy, and that an air-cooled engine that will literally go anywhere in this Country will need but a relatively small amount of fan-supplied air.

The fuel used for the tests described under "Form of Cylinder-Head" on pp. 33 and 49 of my paper was 80 per cent of aviation gasoline with 20 per cent of benzol and was used generally for all the test results quoted in the paper. The compression-ratio in the flat-head cylinder, Type-I, was 5.30 to 1 and in the hemispherical-head cylinder, Type-J, it was 5.37 to 1.

With reference to the Type-K cylinder, satisfactory comparative tests with aluminum and cast-iron heads were not obtained. Owing to defects in the method of valve-gear attachment, fracture of the exhaust port occurred in both aluminum heads that were tested, although no trouble has developed in well over 100 hr. of running with the cast-iron head. The cast-iron Type-K cylinder, however, proved superior in all respects except that of weight to an aluminum cylinder of somewhat different design but with the same bore and stroke. I am rather at a loss to explain the high output and satisfactory operation of the cast-iron cylinder when the very high wall-temperatures are considered. Probably the smooth outline of the hemispherical combustion-chamber, with the resultant smooth gas-flow over the hot surfaces is, in conjunction with the lack of large red-hot areas, mainly responsible for the results obtained, when the cooled valve is used.

Oil-cooling in air-cooled engines was not dealt with in the paper, as this was stressed in my paper on Some Aspects of Air-Cooled Cylinder Design and Development[4]. The efficiency of the internally cooled valve is not dependent on oil for the external abstraction of heat from the stem, although the oil assists this as it does with a normal valve. The type of internally cooled valve developed by the Engineering Division was evolved on an air-cooled cylinder with an open valve-gear and unlubricated valve-stems and guides.

Uniform distribution of air-flow to V-type circumferential-fin air-cooled engines has not proved to be difficult to secure, although of course experiment is necessary. The R.A.E. and Renault V-type engines, having scoop cowls with a propeller directly in front of the entrance to the cowl, needed but little in the way of directional baffling. The most suitable form of cowling is determined readily by a mock-up of the engine, the air being driven into the cowling by a fan and the air distribution checked with a small pitot-head.

While the exhaust turbine-driven fan is probably visionary, it is nevertheless a possibility and was mentioned on that account. While the early exhaust turbine used at the Engineering Division gave considerable trouble with overheating, this is no longer true of the present designs in which the wheel apparently does not, under any conditions, reach anything near a red heat. The whole gas-turbine itself is now extremely reliable.

I should like to take this opportunity of expressing my regret at the death of Mr. McDewell and my sympathy for his family. By his death, the industry loses a very powerful influence toward progress. He was an example of that unfortunately very rare being, the extremely practical engineer who has a thorough knowledge of pure science.

While there is possibly no reason why there should be any doubt about the junction between a cast-iron barrel and cast-in steel fins, nevertheless, in practice, there is considerable uncertainty. Ringing the fins to detect unsoundness is an elaborate proceeding. To admit that it is necessary is just another way of stating that the bond is uncertain. Mr. Dicksee's methods of testing merely add to my opinion that cast-in pieces or inserts of any description are a nuisance in any foundry. Any foundryman is well aware that even cast-in chaplets are likely to be poorly bonded to the casting, and that their use results in danger of leakage under pressure where they are used. I may say that Mr. Dix concurs with my opinion regarding the use of cast-in pieces, both of us having had extensive and rather unpleasant experience with cast-on cylinder-heads and cast-in valve-seat inserts. With reference to cleaning axial fins, the matter is not as simple as Mr. Dicksee states; for instance, in most overhead-valve engines, removal of the fin jacket involves the detachment of the intake and exhaust pipes and usually of part of the valve-gear. In any case, the very presence of the jacket means that the presence of dirt is not at once evident on casual inspection.

While the presence of a considerable coating of dust and

[4] See THE JOURNAL, April, 1922, p. 231.

(Continued on p. 50)

The Use of Acetone in Composite Engine-Fuels

By R. F. Remler[1]

INFORMATION regarding the use of acetone in composite fuels is not extensive in technical literature. Most of it is found in recent patents, the majority of which have been issued in foreign countries. This is due to the higher price of motor fuel in those countries, which has stimulated the search for substitutes for gasoline. In these inquiries engineers have turned to the first possible solution that would permit the use of the present design of engine, that is, a composite fuel.[2] In selecting the ingredients of this type of fuel, they have aimed to utilize the various fuel components obtainable in their particular localities, with the result that the ones available have not always been miscible; or, if miscible, they have possessed properties that are not conducive to good results. To overcome these difficulties, the engineers have been obliged to find a fuel that will act as a common solvent for the various ingredients and to add other desirable properties that are sometimes lacking in the mixture. It appears from some of the recent patents on composite fuels that acetone has been chosen to fulfill this purpose.

The chemical structure of acetone differs somewhat from that or ethanol, or ethyl alcohol, being of ketonic formation. Its chemical composition, however, differs only in that it contains one more carbon atom than ethanol, their respective empirical formulas being C_3H_6O and C_2H_6O. The extra carbon atom gives acetone a higher B.t.u. value, per pound or per gallon, than ethanol, since their specific gravities are approximately the same, 0.792 and 0.789, respectively, at 20 deg. cent. (68 deg. fahr.).

Comparative Heating Values of Acetone and Ethyl Alcohol

	B.t.u. Per Lb.	B.t.u. Per Gal.
Acetone	13,476	89,477
Ethyl Alcohol	13,028	85,985

Acetone is a clear, mobile liquid having an agreeable odor and a peppermint-like taste, It is inflammable and burns with a white smokeless flame. Concentrations of acetone vapor with air up to 2.3 per cent will not flash. Above this point, there is a slight flash, increasing to and reaching a maximum violence at a concentration of 5.5 per cent of acetone vapor, and settling down to a quiet flame at 10.2 per cent.[3] Acetone has a boiling-point of 56.5 deg. cent., or approximately 133 deg. fahr., and is miscible in all proportions with the various fuels used in motor cars.

Acetone may be manufactured by a number of different processes. Prior to the war, it was made on a commercial scale only by the dry-distillation of calcium acetate. The great demand created by the war for this chemical in the manufacture of smokeless powder and as a vehicle for airplane "dope," was the direct cause of the developing of a number of new processes on a commercial basis. The production of acetone by the dry distillation of calcium acetate, however, is still the leading method of manufacture. With the acetone obtained by this process a number of higher ketones also are obtained, namely ethyl-methyl ketone, and light and heavy acetone oils that are not secured from any of the other processes, and that find an extensive use as industrial solvents.

At the close of the war there was a far greater capacity for the manufacture of acetone than was necessary to meet any possible commercial demands, and consequently a number of manufacturers ceased to produce it, while others were compelled to operate their plants at a reduced capacity. The present market for this chemical is probably about 50 per cent of that prior to the end of the war.

Acetone is an excellent engine fuel and in fact approaches the ideal in a number of its properties. Its low boiling-point and the resulting high vapor-pressure at ordinary temperatures facilitate the starting of the engine. Its homogeneity permits uniform evaporation and distribution, and, therefore, it is conducive to smooth running. Its low freezing-point, —94.6 deg. cent. (—138.3 deg. fahr.), prevents its solidification at the coldest winter temperatures.

Acetone will not detonate and can be used in an engine with a compression-ratio as great as 7 to 1, or with a compression-pressure up to 180 lb. per sq. in.[4] It burns with a smokeless flame, does not deposit carbon in the cylinder, and, as far as can be ascertained, has no corrosive action on the cylinder or the various parts of the car with which it comes into contact.

To compete with the other fuels, however, it would be necessary to sell acetone at one-half the price of gasoline, because of the difference in the mileage obtainable. It is not my idea even to suggest acetone as an individual fuel for motor cars, as the present price and supply would not permit such utilization.

Acetone is an excellent blending agent in reducing detonation.[5] It is miscible in all proportions with all the liquid fuels used in motor cars, and in many instances the addition of a small percentage of acetone combines two immiscible liquids into a homogeneous solution.

Ethyl alcohol, 95 per cent, as well as methanol, or methyl alcohol, are not miscible with gasoline in all proportions. As the boiling-point range of gasoline is raised, the range of miscibility of these fuels is decreased, thereby making it more difficult to add liquids of a higher vapor-pressure to the heavier hydrocarbon fuel and thus increase its volatility and distribution in the engine. These particular mixtures as well as others become miscible in all proportions on the addition of acetone in various amounts, enabling also the use of the higher petroleum hydrocarbon fuels.

The chief problems of the present-day motor fuel question regarding the use of heavy hydrocarbons are "fuel-knocks," carbon and starting. These troubles can be reduced greatly by the use of acetone in various percentages, depending upon the boiling-point range of the hydrocarbon complex used and the compression-ratio of the engine.

That acetone reduces detonation when it is used in composite fuels is probably due, first, to the fact that it reduces the deposition of carbon in the cylinders, and, secondly, to the thermolytic decomposition that takes place between 600 and 1000 deg. cent. (1112 and 1832 deg. fahr.), with the formation of methane, ethylene and carbon monoxide.[6] This reaction is endothermic and thus tends to lower the temperature in the cylinders. Acetone also will hold in solution various percentages of water, depending upon the amount of

[1] Industrial fellow, Mellon Institute of Industrial Research, University of Pittsburgh.

[2] See *Bulletin de l'Association des Chemistes de Sucrerie et de Distillerie de France et des Colonies*, vol. 39, p. 215.

[3] See *Journal of the Indian Institute of Science*, vol. 4, p. 1; see also *Transactions of the Chemical Society of London*, vol. 111, p. 267.

[4] See *The Automobile Engineer*, February, 1921, p. 51; and March, 1921, p. 92.

[5] See United States patents, Nos. 1,158,367; 1,331,054; and 1,360,872; see also British patents, Nos. 140,797, 1920; 176,329, 1922, addition to 174.360, 1922; 183,577, 1922; and 185,449, 1922.

[6] See *Berichte der Deutschen Chemischen Gesellschaft zu Berlin*, vol. 43, p. 2821; see also *Bulletin de la Société de la Chimique de Paris*, vol. 46, part 2, p. 268.

acetone present, which acts as an "anti-knock" by reducing the temperature in the cylinders.

Patents have been granted in which claims are made that the addition of acetone in small percentages to gasoline or to various composite engine fuels minimizes the carbon deposited in the engine.[7] I have substantiated this contention by making a number of tests in which large percentages of kerosene were used with gasoline. Acetone also is used in carbon-removing compounds,[8] in which case it acts as a solvent for the asphaltic and resinous materials that bind together the free carbon. I have observed that, by using small amounts, such as 1 qt. of acetone, as the sole fuel in a carbonized engine, most of the carbon deposit was removed. The part remaining was of a fluffy graphitic texture and could easily be taken out.

As a fuel, acetone cannot be used alone with a carbureter containing a cork float, because of its solvent action upon the shellac coating. The claim[9] is made, however, that, where a small percentage is used in a mixture of gasoline and kerosene, its solvent action is inhibited and that it can, therefore, be employed in such composite engine fuels without injury to the float. This claim has also been substantiated by my findings.

It is stated[9] that the action of acetone on kerosene in composite fuels is to regulate its vaporization. I have noted in a number of tests made on composite fuels containing kerosene, to which acetone saturated with acetylene had been added, that a smoother-running fuel was had, making it easier to start the engine and allowing a leaner mixture to be used.

Acetone is the most economical solvent for acetylene, as it dissolves approximately 25 times its volume in the gas at 15 deg. cent. (59 deg. fahr.), while ethyl alcohol dissolves only six times its volume. Numerous patents have indicated the addition of acetone for this purpose.[10]

C. F. Juritz,[11] in reviewing the different methods of manufacture of engine fuel by bacterial processes, finds that "acetol," a fuel consisting of alcohol and acetylene, owes its properties largely to the fact that the addition of acetone to the alcohol raises the absorption of the gas, thus increasing the volatility and calorific value of the mixture.

SUMMARY.

From what has been said it is evident that

(1) Acetone alone is an excellent fuel, easy to start, does not freeze at the coldest winter temperature and will not detonate under a pressure of 180 lb. per sq. in.

(2) It is not only miscible in all proportions with the various fuels used in motor cars, but produces a uniform mixture when it is added in varying amounts to a number of immiscible liquids

(3) When it is added in small amounts to heavy hydrocarbon fuels, it minimizes the deposition of carbon and tends to prevent "fuel-knocks"

(4) Acetone is the most economical solvent of acetylene and, if saturated with this gas and added to composite engine fuels, will produce a smoother-running mixture, facilitate starting and permit running on a leaner mixture

[7] See United States patents, Nos. 1,296,832 and 1,399,227.

[8] See United States patents, Nos. 1,287,589; 1,307,562; and 1,310,985.

[9] See United States patent, No. 1,399,227.

[10] See British patents, Nos. 105,256, 1916; and 178,498, 1920; see also Canadian patent, No. 221,090, 1922.

[11] See *South African Journal of Industries*, vol. 4, p. 905.

SERVICE[1]

I am Service. But I am more than a name, more than a bloodless definition between dry dictionary covers.

I am energy, motion, speed.

I am foresight.

I am system.

I am common sense.

I am Alexander Bell, lengthening the tongues of men.

I am harmony.

I am Morgan, standing between panic and prosperity.

I am cooperation.

I am Westinghouse, stopping trains with wind.

I am patience.

I am Morton, making the surgeon's knife a blessing instead of an agony.

I am flexibility.

I am analysis.

I am Marshall Field, saying "The Customer is always right."

I am initiative.

I am Carnegie, king of salesmen.

I am detail.

I am Burbank, rending material wealth from the plants.

I am the crawling ant that rests not; I am the great ship upon the sea.

I am Goethals, master surgeon of a continent.

I am Pasteur, a whole life one long luminous trail of service.

Ay, I am Service!

I run through life, a golden thread with the strength of steel.

I speak all tongues.

I am the German in the laboratory, the American in the market place.

I am Smith, Jones, Brown, whoever you please that moves forward, adjusts himself to the hour, the place and the master.

I am the donkey-engine, I am the shining rails of a Harriman, I am the racing camel of the desert.

I am salesmanship incarnate.

I am the practical idealist of commerce.

I am progress.

I am the child of necessity, fathered by demand.

I pass swiftly over the swollen plains and make the epic of the wheat; I bring the sullen iron from its beds of fire.

I fill the warehouse with gold and the home with content.

I am the chemistry of action.

I was born with the world, I have made possible the ages, I am the most vital, imperious, necessary element of modern life.

I am the mother of effort, the genius of industry, the mate of life itself.

I am the ambassador of plenty.

And I am at your service.—G. B. Clarkson.

[1] *Service.* Any work done for the benefit of another; the act of helping another or of promoting his interests in any way; hence, also, a benefit or advantage conferred, or use and advantage in general. Standard Dictionary.

Vol. XIII July, 1923 No. 1

Importance of Better Automobile Head-Lamps and Proper Adjustment

By R. N. Falge[1] and W. C. Brown[1]

Semi-Annual Meeting Paper *Illustrated with* Photographs and Diagram

THE accurate construction and easy adjustability of automobile head-lamps, though they have received much attention, are still susceptible of further improvement. If motorists realized that the road would be illuminated better, objectionable glare could be avoided and a better and safer head-lamp would be secured by properly adjusting the head-lamps now in service, an immediate and far-reaching improvement would be effected.

Views are given of tests made with the common type of head-lamp with a parabolic reflector to show the effects produced by placing the source of light at the focal point, by moving it forward, backward, above and below this point, and also by cylindrical flutes in the glass and by horizontal prisms. The head-lamp is shown to be very sensitive inasmuch as the distances from the filament to the reflector are very short when compared with those to which the light is projected. A type of lens is described that will compensate for the commercial variations in the position of the filament and at the same time distribute the light effectively, converging or diverging the rays laterally while maintaining the top or cut-off substantially at the level of the head-lamp. As the maximum intensity should be placed as near to the top as possible to illuminate the road-bed most effectively, and as the eye accommodates itself slowly to changes of intensity, the lens takes advantage of these characteristics by spreading and bending the light in each zone by different amounts.

The requirements are given for the uniform and satisfactory service of lamps and of such parts as filaments, sockets, reflectors, lenses, doors and mountings, the underlying idea being the use of devices that will obviate the necessity for focusing and leave to the motorist only the simpler adjustment of aiming.

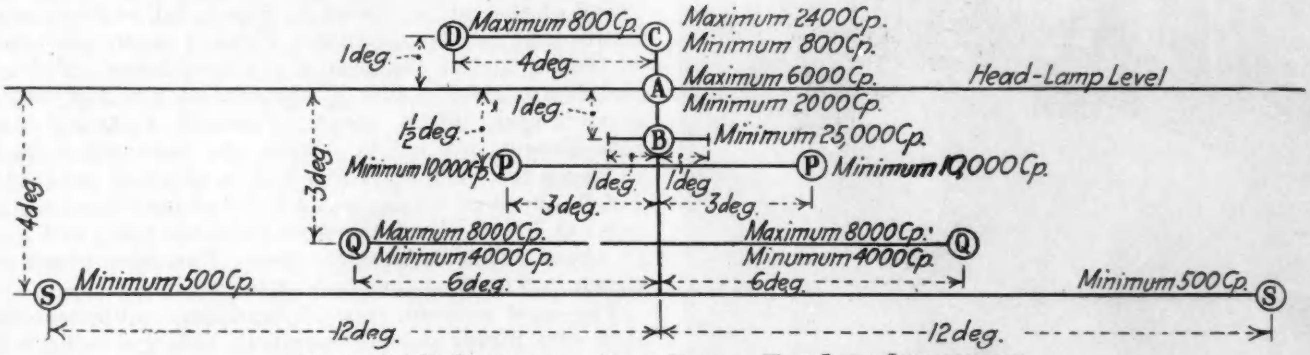

Fig. 1—S.A.E. Standard for Motor-Vehicle Head-Lamp Illumination

DESPITE the progress that has been made in the last few years in improving automobile head-lamps, the conditions prevalent on the main highways of the Country, particularly those near large cities, remain unsatisfactory. The genuine concern that is apparent everywhere, the fact that State legislatures in attempting to improve conditions are finding it necessary to strengthen the laws, the fact that the Society is willing to devote an entire evening to the problem, all indicate that this matter, which has so direct a bearing on the safety of the motorist, has not been handled so effectively as have others of less importance that have to do merely with road performance and repair bills.

Without question, if motorists generally could be made to realize two facts, an immediate and far-reaching improvement in head-lamps would result. These are that

(1) It is entirely possible to get better road illumination, and at the same time prevent objectionable glare, by properly adjusting the majority of the head-lamps now in service

(2) A driver, who makes the proper adjustments now, without waiting for others to make them, not only will remove the annoyance he is causing everyone else, but also will provide himself with a head-lamp that is better and safer and that will make it easier for him to pass cars with glaring head-lamps

The erroneous idea that headlamp adjustments are made for the sole benefit of others would more easily be dispelled and the cooperation of motorists in improving conditions would be obtained more readily, if motorists were provided with accurate equipment, simply adjustable, and with instructions so clear and so comprehensive that they might easily be followed and intelligent allowance be made for such commercial variations in the equipment as would affect the distribution of light.

Underlying Principles

Good head-lamps without objectionable glare may be obtained by concentrating the rays emitted in all directions from the filament of the lamp into a shallow band of light having a candlepower hundreds of times greater than that of the lamp, directing this band of light straight ahead of the car and tilting it so that the top edge or cut-off of the beam is at the level of the head-lamp. The beam should spread to the sides far enough to illuminate the ditches and turns. A diffused light of low-intensity sufficiently strong to reveal pedestrians,

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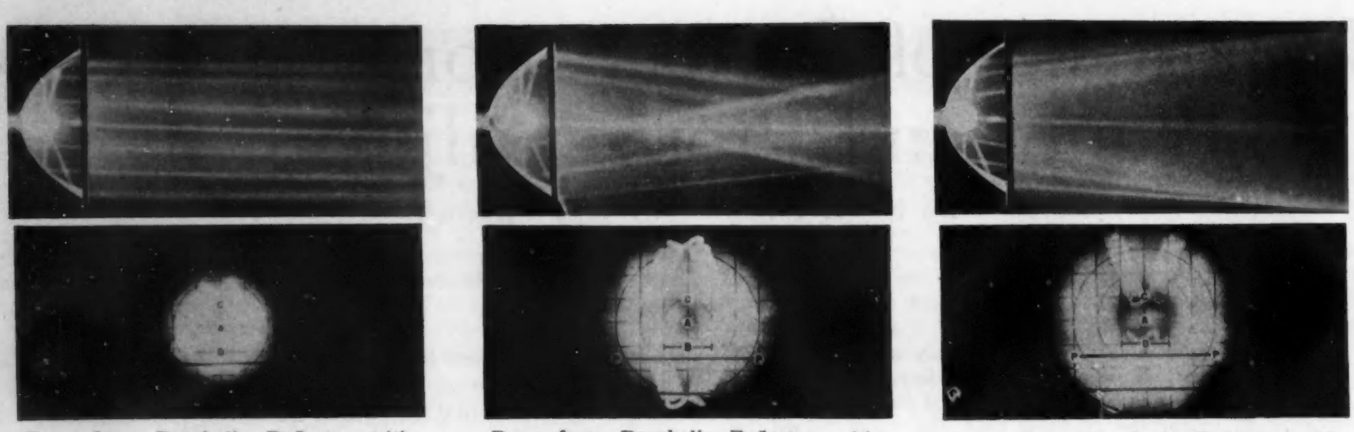

Rays from Parabolic Reflector with Light Source at Focus
Cross-Section of Beam with Light Source at Focus

Rays from Parabolic Reflector with Light Source Ahead of Focus
Cross-Section of Beam with Light Source Ahead of Focus

Rays from Parabolic Reflector with Light Source Back of Focus
Cross-Section of Beam with Light Source Back of Focus

FIG. 3—HOW THE RELATIVE POSITIONS OF THE LIGHT SOURCE AND THE FOCUS OF A PARABOLIC REFLECTOR AFFECT THE DISTRIBUTION OF THE RAYS AND THE CROSS-SECTION OF THE BEAM

FIG. 2—HOW THE TEST POINTS OF FIG. 1 APPEAR TO A DRIVER

overhanging obstructions and the like, but not enough to blind approaching drivers, is desirable above the cut-off.

Engineers, who have given the subject of automobile head-lamp illumination careful study supplemented by extensive road tests, have found that good driving-light without objectionable glare will be obtained when the rays of light, directed toward certain points on the road ahead of the car, as shown in Fig. 1, fall within certain limits that can be specified. Point *A* is directly ahead of the car and at the level of the head-lamps. Points *C* and *D* are glare points at the level of the approaching driver's eyes, 100 ft. ahead. Points *B*, *P*, *Q* and *S* are road-illumination points. When the head-lamps are 36 in. above the road, point *B* is 172 ft. ahead of the car; *P*, 114 ft. ahead of the car and 6 ft. to either side of the car axis; *Q*, 57 ft. ahead and 6 ft. to either side; and *S*, 43 ft. ahead and 9 ft. to either side. The same points are shown in Fig. 2 as they appear to the driver.

The most common type of head-lamp equipment consists of a highly polished parabolic reflector using a 21-cp. gas-filled lamp in a socket that may be moved forward or backward along the reflector-axis to compensate for variations in the position of the filament in commercial lamps, with means for spreading the beam toward both sides and in many cases for bending it downward.

The parabolic reflector may be visualized as being com-

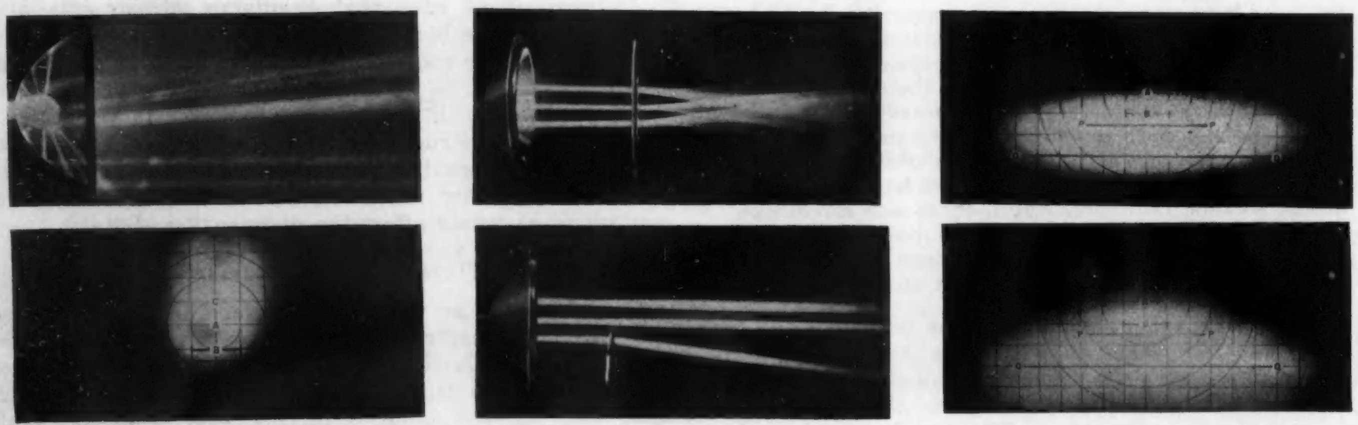

FIG. 4—THE UPPER AND LOWER LEFT VIEWS SHOW THE DISTRIBUTION OF THE RAYS FROM A PARABOLIC REFLECTOR AND THE CROSS-SECTION OF THE BEAM WHEN THE LIGHT SOURCE IS BELOW THE FOCUS; THE NEXT PAIR ILLUSTRATE HOW THE LIGHT RAYS CAN BE SPREAD BY USING VERTICAL FLUTES (ABOVE) AND (BELOW) HOW A RAY OF LIGHT CAN BE BENT WITH A HORIZONTAL PRISM, BOTH VIEWS BEING TAKEN FROM ABOVE THE HEAD-LAMP; WHILE THE PAIR OF VIEWS AT THE RIGHT SHOW THE CROSS-SECTION OF THE BEAM OBTAINED WITH UNIFORM SPREADING FLUTES (ABOVE) AND (BELOW) A MORE DESIRABLE BEAM CROSS-SECTION IN WHICH THE RAYS FROM DIFFERENT SECTIONS ARE BENT AND SPREAD IN VARYING AMOUNTS

posed of a multitude of small flat mirrors, each of which is so placed that a ray of light from one point, known as the focal-point, will be reflected in a direction parallel to the axis of the reflector. When all the reflected rays are parallel, the diameter of the beam at any distance would, of course, be the same as that of the reflector-opening. When the rays of light come from any other point, the angles at which they strike will be changed, and only such rays as happen to be in line with the focal-point will be reflected parallel to the reflector-axis.

The filament of an automobile lamp must have some size, and it cannot, therefore, all be located exactly at the focal-point. Rays that come from points on the filament not at the focal-point are not reflected exactly parallel to the reflector-axis. The farther from the point they happen to be, the more will they diverge. Actually, an image of the filament is reflected from every point on the reflector. These filament images increase in size with the distance and, at a point 20 or 30 ft. ahead of the car, when the filament is properly placed about the focal-point, they overlap and intermingle in a manner so as to produce a fairly uniform intensity over the cross-section of the beam. In the upper half of Fig. 3 and in the view in the upper right corner of Fig. 4, one side of an automobile head-lamp reflector has been cut away to show the light-rays passing through holes in a nearly opaque coating applied to the bulb of a 6 to 8-volt 21-cp. lamp and being redirected by the reflector. The rays were made visible and photographed in a smoky atmosphere.

The upper left portion of Fig. 3 shows what will happen to the light-rays when the lamp filament is centered accurately about the focal-point, while the lower left view shows a cross-section of the beam as thrown on a screen 20 ft. ahead. The two superimposed images of the filament were obtained by first exposing the entire beam and then placing over the reflector-opening an opaque shield with two small holes in it, one above and the other below the axis, to allow only such light-rays as come from the small areas back of the openings to escape. The images referred to are barely discernible in this illustration; they show clearly in the other two lower views. Focusing cards based on this princople are sometimes furnished to

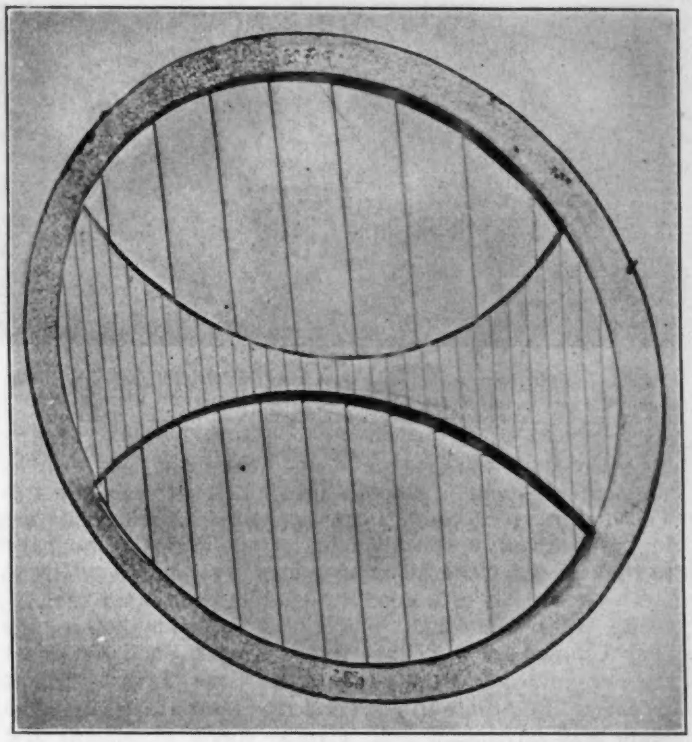

FIG. 5—A LENS DESIGN THAT SIMPLIFIES HEAD-LAMP ADJUSTMENT BY ELIMINATING THE NECESSITY FOR FOCUSING

The Photograph from Which This Illustration Was Made Was Taken at an Angle To Emphasize the Prisms

assist in making adjustments. Obviously, inaccurate reflectors cannot be expected to give satisfactory results.

The upper central and right views of Fig. 3 show how the reflected rays change in direction when the light source is placed ahead and back of the focal-point. The corresponding lower views show that the beams are less concentrated than when the source of light is about the focal-point and, since the light is distributed over a larger area, the candlepower is correspondingly less.

The two views at the left of Fig. 4 show the effect

FIG. 6—LIGHT DISTRIBUTION PROVIDED BY ACCURATELY CONSTRUCTED HEAD-LAMP EQUIPPED WITH THE NON-FOCUSING LENSES SHOWN IN FIG. 5

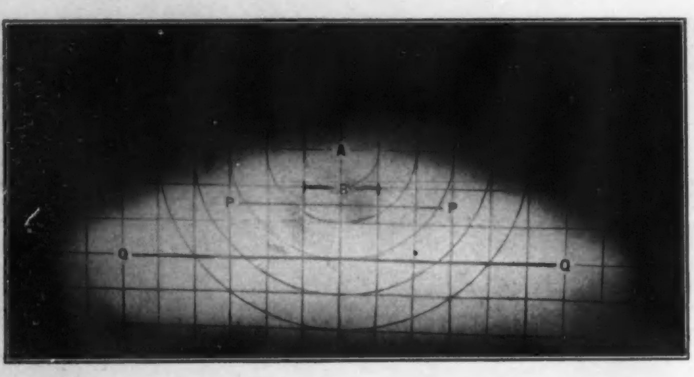

FIG. 7—CROSS-SECTION OF THE BEAM FROM HEAD-LAMPS EQUIPPED WITH NON-FOCUSING LENSES

upon the individual rays and upon the beam as a whole, when the filament is placed slightly below the focal-point. The distortion of the beam on account of axial variation in the location of the filament is in a direction opposite to that in which the filament is moved from the axis.

The essentials of a good automobile head-lamp have already been mentioned briefly. It is evident that the beam, shown in Fig. 3 at the lower left, will not meet these requirements because it does not have sufficient spread to illuminate ditches and turns satisfactorily. The beam may be spread over a wider angle by placing the filament ahead or back of the focus, as shown in the lower central and right views, but even then it will not be wide enough. Furthermore, the increase in width will be accompanied by a corresponding increase in the depth of the beam and when the head-lamps are tilted to avoid glare, too much of the light will be directed toward points near the car. Better lighting results are to be obtained by spreading the beam as shown in the lower left corner of Fig. 3. This may be accomplished either in the reflector or in the cover glass.

The upper central view of Fig. 4 shows the spreading effect of cylindrical flutes in the glass, the prismatic action increasing from the center to the outer edges of the flutes. The upper right view shows how the concentrated beam of the lower left view of Fig. 3 may be spread by vertical flutes in either the reflector or the cover glass.

The lower central view of Fig. 4 shows the bending effect of horizontal prisms in the glass. The entire beam may be titled uniformly to strike below the point *A*, as shown in the upper right corner, by tilting the entire head-lamp or the reflector alone, or by using simple horizontal prisms of uniform bending-power over the entire face of the lens. The advantage of horizontal prisms occurs when the lens is designed so that the light from different sections of the reflector is bent and spread by varying amounts to improve the distribution, as shown in the lower right corner of Fig. 4.

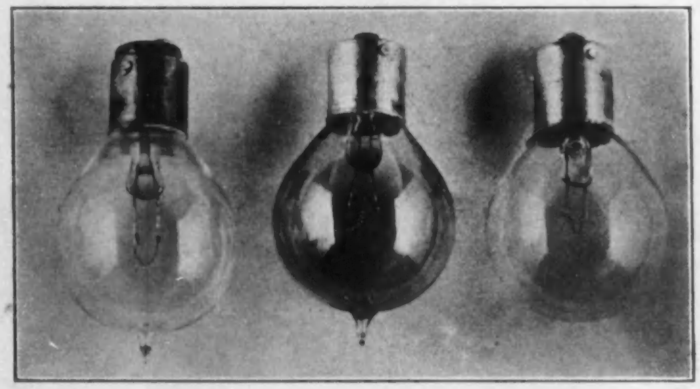

FIG. 8—TYPICAL AUTOMOBILE HEAD-LAMP BULBS

From Left to Right These Are a Lamp Manufactured by Precision Methods, a Bulb That Has Become Darkened Due to a Large and Sagging Filament and a Bulb with an Improperly Placed and Excessively Large Filament

It is evident, from this discussion of the fundamental principles underlying the operation of the head-lamp, that it is a very sensitive device. The distances from the filament to the reflector and the lens are so short as compared with the distances ahead of the car to which the light is projected that satisfactory results cannot be expected with inaccurate or poorly adjusted equipment.

Even when the equipment is good, the problem of securing proper adjustment still remains. Greater simplicity will help in its solution. The proper adjustment of all devices in general use today necessitates both focusing and aiming. It appears impossible to eliminate the aiming adjustment; to design redirecting equipment that will eliminate the focusing adjustment is both possible and practicable.

LENS DESIGN THAT ELIMINATES FOCUSING

A design of lens that, with accurate equipment, will compensate for commercial variations in the position of the filament in the lamp and at the same time distribute the light effectively in the beam is shown in Fig. 5. It takes advantage of the fact that rays reflected from a parabolic surface converge or diverge as the light source is moved ahead or back of the focal-point, as is illustrated in the upper central and right portion of Fig. 3. The light-rays passing through the middle zone are titled downward slightly and form the upper part of the beam. As the filament is moved forward or backward, the rays in this zone converge or diverge laterally and maintain the top, or cut-off, of the beam substantially at the level of the head-lamp. The rays of light from the upper and lower zones tend to rise or fall as the lamp is moved, but they are deflected downward sufficiently by prisms so that they will not rise above the top of the beam from the middle zone when the filament is moved forward or back of the focal-point through predetermined and relatively wide limits. Incidentally, beams from reflectors that are surfaces of revolution but not truly parabolic in contour ordinarily will have a sharper cut-off at the top with this design of lens than with others that spread the beams.

To illuminate the road-bed most effectively, the maximum intensity should be placed as near the top of the beam as possible, whence it will be projected farthest down the road. Since the eye accommodates itself rather slowly to changes of intensity, the candlepower should fall off toward the bottom and sides of the beam to illuminate the road-bed evenly and to eliminate the bright spots that reduce the visibility of points beyond them. These characteristics have been incorporated into the lens shown in Fig. 5, by spreading and bending the light in each zone by different amounts. The middle zone bends the light passing through it very slightly and the spreading effect is hardly more than is necessary to smooth the beam. The lower prism bends the light considerably more and spreads it sufficiently to illuminate the sides of the road near the car and assist in making turns. The upper zone has an intermediate spread and tilt. When focused to give the best results, the beam has the form shown in Fig. 7, from which it will be noted that its boundaries follow fairly closely the test stations that the Society has determined upon in specify-

ing desirable road illumination. The design is such that there is sufficient stray light above the horizontal to illuminate pedestrians, overhanging obstructions and similar objects.

This lens can be designed to compensate for variations of position of the filament of various magnitudes within the commercial limits ordinarily accepted in lamp manufacture. The distribution of light becomes less desirable as the tolerances are increased. The most satisfactory compromise between light distribution and accuracy in lamp assembling appears to result when the lens is designed to compensate for variations of 3/64 in. ahead or back of the focus; in other words, for the tolerances to which tipless precision lamps are now being manufactured.

The permissible axial variation of 3/64 in. to which these same tipless precision lamps are manufactured is also acceptable. Axial variations tend mainly to raise or lower the entire beam without seriously distorting it. They may be compensated for with a fair measure of success by aiming the head-lamps.

CONSTRUCTIONAL FEATURES DEMANDING ATTENTION.

Lamps should be uniform and efficient in performance throughout their life. They should have highly concentrated filaments to give the minimum beam-divergence. The filaments should be placed accurately with respect to the locking-pins and to the axis of the base to minimize beam distortion. They should not sag in service (See Fig. 8).

Sockets should grip the bases firmly and fit the reflector sleeves closely so that the lamps shall not be jarred out of adjustment when the car passes over rough spots in the road. The socket and the reflector axes should coincide. The electrical resistances at the contacts should be low to minimize the loss of light.

Reflectors should be highly efficient and should not warp or tarnish in service. Inaccurate contour causes glare and unsatisfactory road illumination (See Fig. 9).

Lenses should be free from hills and hollows caused by the careless polishing of the glass molds. Their design should be based on sound engineering principles.

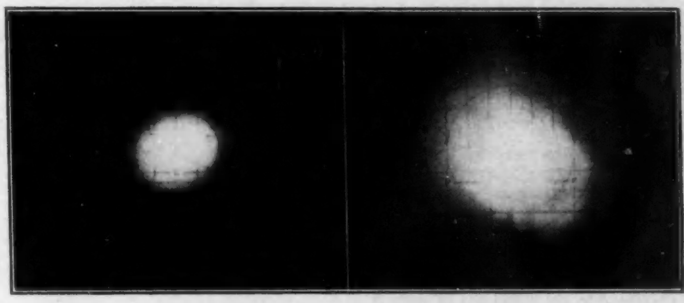

FIG. 9—HOW INACCURACIES IN THE CONTOUR OF REFLECTORS FREQUENTLY RENDER OTHERWISE GOOD EQUIPMENT INEFFECTIVE

The View at the Left Shows the Cross-Section of the Beam from an Accurately Made Reflector, While That at the Right Is the Cross-Section of the Beam from a Reflector That Was Inaccurately Manufactured. Both Reflectors Were Taken from the Regular Production of the Two Factories and the Photographs Were Reduced to the Same Extent

Doors should be easy to remove and to replace. Means should be provided to prevent the lens from rotating.

Universal mountings should be provided to facilitate aiming. The importance of proper aiming cannot be overemphasized.

Adjustments should be carefully made before the car is delivered to the owner and simple but adequate instructions for readjusting should be given in the instruction book.

The fact that a few of the parts manufacturers are able to furnish equipment that will meet most of the requirements discussed above at little if any increase in price is proof that it is today commercially possible and practicable to attain the required standards of accuracy. Satisfactory performance, however, is unquestionably of sufficient importance to justify the small additional cost of thoroughly satisfactory equipment when it is necessary.

The use of devices that will obviate the necessity for focusing and that will leave to the motorist only the simpler adjustment of aiming should increase the number of cars with properly adjusted head-lamps and should assist materially in regaining the cooperation of car-owners in improving head-lamp conditions throughout the country.

FEDERAL AID ROAD CONSTRUCTION

FEDERAL aid road construction reached a new high water mark in 1922, when the mileage of new road added to the growing system of Government-aided highways exceeded 11,000 miles. The exact length was 11,374.7 miles. This was almost twice as much as the mileage constructed in 1921, the best previous year, which added only 5943 miles; and it was more than seven times as great as the mileage completed in the first 4 years of operation under the Federal Aid Road Act.

FEDERAL AID PROJECTS COMPLETED DECEMBER, 1922, BY TYPES OF CONSTRUCTION

Type	Mileage Completed
Graded and Drained	3,286.4
Sand-Clay	2,235.1
Gravel	7,621.3
Water-Bound Macadam	473.4
Bituminous Macadam	666.4
Bituminous Concrete	681.8
Portland Cement Concrete	3,542.8
Brick	310.6
Bridges	31.4
Total	18,849.2

The total cost of the roads completed in 1922 was over $216,000,000, of which the Federal Government's contribution was more than $90,000,000. This record, both as to total cost and Federal aid payment, was nearly twice as great as the accumulated totals for the 6 preceding years.

The total of Federal funds appropriated up to the end of the year, less the deduction for administration, was $388,625,000. Of this amount, $139,227,437.80 had been paid for completed projects. An additional amount of $70,269,119.08 had been paid in the form of progress payments on projects under construction as part payment of the $149,663,762.92 allotted to such projects, a further sum of $49,984,248.44 had been allotted to definite projects that had not yet been placed under construction and a balance of $49,749,550.84 was entirely unobligated. Including the newly approved projects, projects for which plans were under way and all projects in the pre-construction stages the total mileage of projects initiated and approved for Federal aid and in various stages of completion or completed was 45,185.7 miles.

The table in the adjoining column shows that the mileage of gravel roads is the greatest.

The average cost of all types per mile, exclusive of bridges, for the whole period of operation is $16,800. For the year 1922 the cost was $18,500.—H. S. Fairbank in *The Constructor.*

Cooling Capacity of Automobile Radiators

By E. H. Lockwood[1]

Annual Meeting Paper *Illustrated with* Charts

FOLLOWING the presentation of this paper as printed in the January, 1923, issue of The Journal, additional data were used by Professor Lockwood to constitute a third part to the original paper, which is published herewith, together with the discussion, both oral and written, that was induced at the Annual Meeting.

For the convenience of the members, an abstract of the complete paper follows; and the text of the additional part of the paper is then presented, preceding the discussion.

ABSTRACT

THE heat-dissipating properties of three types of radiator core have been investigated at the Mason Laboratory, Yale University. These include the fin-and-tube, the ribbon and the air-tube groups, so classified according to the flow of the water and the air. The ratio of the cooling surface to the volume is shown to be nearly the same in the fin-and-tube and the air-tube cores, while that of the ribbon core is somewhat greater. A formula is derived for computing the heat-transfer coefficient, which is defined as the number of heat units per hour that will pass from one square foot of surface per degree of temperature-difference between the air, and the water and is the key to radiator performance, as by it almost any desired information can be obtained. When the heat-transfer coefficients have been found for a sufficiently wide range of water and air-flows the cooling capacity of a radiator can be computed for any desired condition. In an appendix five fundamental and six derived formulas are given. These cover such topics as pump circulation, thermo-syphon circulation, limiting depth of core required, final temperatures, weight of water-flow and the like. The results of applying the formulas to six cores that were selected as representative of the three main types are illustrated by a series of charts.

The cooling demands on the radiator when the engine is in high gear and running at full load, are stated to be a maximum at a car-speed of 25 m.p.h. A new rule is offered for determining the size of radiator that consists of allowing 50 cu. in. of core-volume for each horsepower developed at a car-speed of 25 m.p.h. Confirming evidence is adduced from dynamometer tests of 31 different makes of automobile, which shows that the average for the whole group was 51 cu. in. of core-volume per maximum horsepower at the above named speed.

This study of present-day cars shows that cores for the thermo-syphon system averages 15 per cent larger than for the pump system; and that little difference exists between the sizes of the fin-and-tube and the ribbon cores for equal horsepower. The author's final conclusions are that the different types of core are nearly on a par for cooling, and that the difference between thermo-syphon and pump cooling is less than is popularly supposed.

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Radiator Capacity and Engine Horsepower

An interesting point in radiator-design is to find the car-speed at which the cooling ability of the radiator will be taxed most severely. The limiting speed is not the highest, because the horsepower falls off rapidly at high speeds; nor is it the lowest, because the fan helps out the radiator at low speeds. This discussion relates, of course, only to the full power while running in high gear.

The determining factors are the power-curve of the engine and the cooling-capacity of the radiator, both being laid out on the car-speed as the base line. An example is given in Fig. 6, where these curves are plotted for a well-known light six-cylinder engine, the radiator of which is known to give satisfactory cooling. The power-curve in the figure was taken from dynamometer tests at wide-open throttle. The cooling-capacity curve was computed from formulas given in the paper, in which the average values for ribbon cores were used. Conservative values were taken, such as a summer temperature of 80 deg. fahr., and a jacket-heat of 4000 B.t.u. per hr. per engine-hp. The latter figure is very liberal, since 3000 B.t.u., or even less is used frequently for this item.

It will be observed that the cooling-curve thus plotted cuts the power-curve in two points, and slopes in the same general direction. Where the horsepower-curve lies above the cooling-curve, it indicates deficiency of cooling. This is seen to be a maximum at about 25 m.p.h. on the car-speed scale, which is, accordingly, the speed sought; that is, the speed at which the radiator will be taxed most in cooling the engine. It follows, that if the radiator will just cool the engine at a speed of 25 m.p.h., it will have reserve capacity at either higher or lower speeds.

A simple and logical rule for radiator design is to proportion the core for a car-speed of 25 m.p.h., with a capacity equal to the maximum horsepower that the engine can develop at that speed. When this rule is applied to the engine of Fig. 6, it yields the result that 50 cu. in. of core is required for each horsepower, or 50 x 26 = 1300 cu. in. for the whole core.

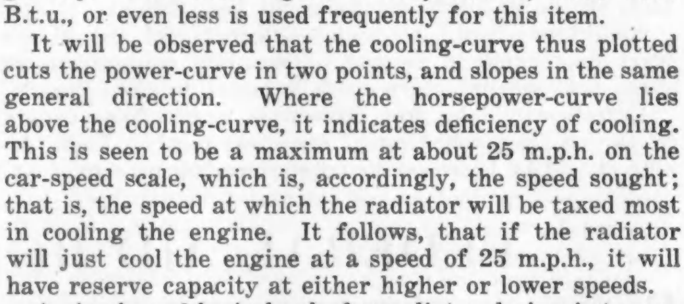

Fig. 6—Curves Showing the Relation between Engine Horsepower and the Cooling Capacity of the Radiator for Various Sizes of Engine and Different Speeds

Radiator Sizes in Practice

If the conclusions drawn in the last section are true, it follows that the maximum cooling demands occur at a car-speed of 25 m.p.h., and that a core-volume of 50 cu. in. for each horsepower developed at that speed with open-throttle should cool the engine properly. It will now be in order to discover whether the radiators used in modern automobiles confirm these conclusions.

Considerable evidence is at hand bearing on this subject from the drum-dynamometer records at the Mason laboratory at Yale University. Upward of 100 vehicles have been subjected to power tests on the drums, representing more than 40 makes of automobile. In most cases, the radiator-core volume was measured and recorded at the time of the test. Excluding the cases where the records were incomplete as to core-type or size, 17 tests have been selected in which ribbon cores with pump circulation were used.

Some particulars of the 17 tests are recorded in Table 2. Column 1 contains a serial number for identification. The successive columns give piston-displacement, maximum horsepower developed at 25 m.p.h., total core-volume, core-volume per cubic inch of displacement and core-volume per maximum horsepower at the assigned speed. In addition to the figures in the body of the table, the average of each column is given on the bottom line. The figures in Column 6 represent the core-volume in proportion to horsepower. Although the figures vary from a minimum of 41 to a maximum of 71, the average is 51, or very nearly the value of 50 that was deduced in the last section for this type of core.

The core-volume can also be computed from the piston-displacement, as well as from the horsepower; and this rule may have occasional application. This rule can be deduced from the average at the bottom of Column 5, and may be stated thus: The core volume should be 5 cu. in. for each cubic inch of piston-displacement. There is a close relation between piston-displacement and horsepower, but it is better to use the latter in proportioning a radiator, if possible.

TABLE 2—DATA FOR RIBBON CORES WITH PUMP CIRCULATION

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Serial Number	Piston Displacement, Cu. In.	Maximum Power at 25 M.P.H. Hp.	Total Core Volume, Cu. In.	Core Volume per Cubic Inch of Displacement, Cu. In.	Core Volume per Maximum Horsepower, Cu. In.
100	224	22	1,440	6.4	65
112	424	45	2,300	5.4	51
125	228	30	1,330	5.7	44
143	224	23	1,110	5.0	48
147	340	34	1,390	4.1	41
162	247	28	1,940	7.8	69
173	226	21	1,500	6.6	71
176	298	28	1,590	5.3	57
179	171	17	850	5.0	50
193	525	54	2,250	4.3	42
197	361	32	1,620	4.5	51
212	191	23	1,010	5.3	44
214	289	28	1,360	4.7	49
222	242	25	1,200	5.0	48
224	572	42	2,270	4.0	54
228	242	27	1,280	5.5	48
229	525	41	2,210	4.2	54
Average..	312	31	1,570	5.0	51

TABLE 3—SUMMARY OF AVERAGES FOR FIN-AND-TUBE CORES AND THERMO-SYPHON SYSTEMS

Circulation System	Type of Core	Number of Examples	Cubic Inches per Horsepower
Pump..........	Ribbon.........	17	51
	Fin and Tube...	6	43
	Both..........	23	47
Thermo-Syphon..	Ribbon.........	3	55
	Fin and Tube...	5	55
	Both..........	8	55

Table 2 relates only to ribbon cores, but similar tables have been made for fin-and-tube cores, and for the thermo-syphon system of circulation. These tables will not be presented here, but a summary of their averages is given in Table 3. The results in Table 3 can be said to represent fairly the average practice in radiator sizes. They can be supplemented by facts drawn from individual tests.

The largest core-volume, relatively, was found in a four-cylinder, sleeve-valve engine, having 71 cu. in. per maximum horsepower at 25 m.p.h. The smallest core-volume was found in a V-type, eight-cylinder engine, having 33 cu. in. per maximum horsepower at 25 m.p.h. Curiously enough, both engines were cooled with fin-and-tube radiators with thermo-syphon circulation. The smaller radiator is said to be satisfactory, and the larger one is known to cool indefinitely at full power in low gear.

From the above results of the examination of the radiators used in various automobiles, it appears that radiators for the thermo-syphon system usually are made about 15 per cent larger than for pump circulation, and that the different types of core give about equal cooling.

Little attention has been paid in this paper to the engine fan as an adjunct to the cooling of the radiator. Without doubt, a powerful fan, well-housed-in to draw air from the core, will increase greatly the capacity of any radiator.

THE DISCUSSION

PROF. E. H. LOCKWOOD:—My paper naturally falls into three parts; first, the mathematical theory of radiator testing, as developed in the mechanical laboratory of Yale University in cooperation with local manufacturers; second, the application of the theory to several classes of radiator, using data obtained from a wind-tunnel apparatus, to determine what differences existed in the various types of core for heat dissipation; and third, an examination of existing automobiles to see whether the radiator supplied by the builders confirmed the conclusions drawn from the laboratory experiments. The third part was not included in the paper as printed in the January, 1923, issue of THE JOURNAL, as this material was collected after the paper was written. It was made possible by the records of the rear-wheel dynamometer in the Mason Laboratory, where many chassis tests have been conducted during the past 5 years, including measurements of the radiator as well as engine horsepower.

The mathematical theory is embodied in 11 formulas given in the Appendix. Formulas (3), (4) and (5), express the heat radiated by the core in different forms, depending on the quantity of water, the quantity of air or the extent of surface. By combining formulas (3), (4) and (5) and eliminating terms, formulas (6) and (7) are derived. Formula (6) is of importance, because it

gives the cooling capacity of the core with two troublesome variables, the exit temperatures of water and air, eliminated. The other quantities in formula (6) can be assumed or determined in advance without great difficulty. The airflow through the core can be computed by using formula (2), after measuring the free-air area and the velocity of the air through the free-air area by wind-tunnel experiment. The latter velocity can be expressed in terms equivalent to a given car-speed.

As the relation between car-speed and air velocity through the core is still apparently one of the unsettled points in radiator testing, a few words on this point are in order. At a given car speed in miles per hour, S, a pressure against a flat plate normal to the airflow, expressed in inches of water column, h, will be produced. The theoretical relation between the speed and the pressure in this case is expressed by $h = S^2/2070$. In a specific example if the car speed is 25 m.p.h., the water-column pressure by the formula is 0.302 in. Duplication of this car-speed in the test apparatus will be accomplished by a total pressure difference on the opposite sides of the radiator equal to 0.302 in. of water column. The air velocity through the core is known in terms of the pressure difference; hence, it is known also in terms of car-speed.

A description of the test apparatus was omitted from the paper; hence a diagrammatic drawing is shown in Fig. 7. The radiator is sealed in an opening in the side

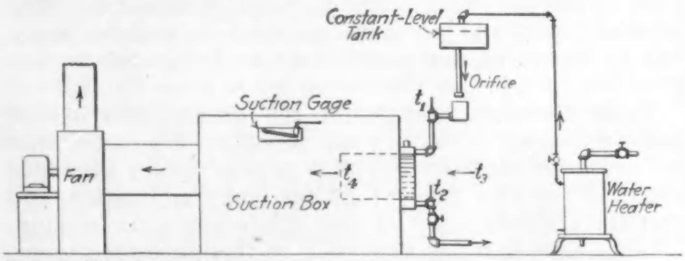

FIG. 7—DIAGRAMMATIC DRAWING OF THE APPARATUS EMPLOYED IN MAKING THE RADIATOR TESTS DESCRIBED IN THE PAPER

of an air-tight chamber that, in turn, is connected to a suction fan. After the air has passed through the radiator, it is confined in a short tunnel for temperature measurement. The pressure difference is measured between the suction chamber and the room from which the entering air flows. The water supply is heated by a closed steam-coil heater; thence, it flows to an elevated tank where its level is maintained by a float and a valve. The water is metered by an orifice below the constant-level tank; thence, it flows through a pipe to the radiator. The level in the radiator is maintained by a needle-valve in the outlet pipe. The water temperatures are measured by mercurial thermometers immersed in the water pipes near the radiator. The loss of head in friction of the core and pipe connections is measured by gage glasses attached to the pipes leading to the radiator.

In using this apparatus to measure the heat-transfer coefficients, the procedure has been to select three orifices that, under the constant head, will give water-temperature drops of 15, 30 and 45 deg. fahr., approximately. In this way a proportionate amount of water-flow for each size of core will be obtained, covering a range from thermo-syphon to moderate pump circulation. With each orifice in place, the fan speed is adjusted to give air-pressure differences of 0.20, 0.50 and 0.90 in. of water on opposite sides of the core, corresponding to car-speeds of 20, 32 and 44 m.p.h.

CHAIRMAN T. J. LITLE, JR.:—Is Professor Lockwood familiar with the design of radiators that are used in connection with the steam-cooling of automobile engines? Steam-cooling has been discussed at some length lately and I understand the radiator has to modified somewhat; some baffling is necessary. When an engine is cooled with steam, a slightly different problem is placed on the radiator than when it is cooled with water.

J. J. CUCURELLO:—The passages for the circulation of steam in the cellular-type core are so narrow that they are easily clogged by sediment in the system, so that in time the radiator as a whole would drop down in condensing capacity and burst and leak. The only type we found that gave good results was the fin-and-tube type, consisting of 3/8-in. outside-diameter tubes with relatively small fins, the projected area of which is possibly about 50 per cent of the total surface-area. The size of the fin was 3/4-in. square, and the best results were secured when the fins were spaced about six to the inch. We are satisfied that the only type of core that will handle the steam-condensing proposition for automotive use is a core like that used at present in the condenser on a certain steam automobile.

Professor Lockwood's paper, as applied to the passenger car, motor truck and tractor, gives a direct method of computing radiator-core proportions when the heat-transfer coefficient, atmospheric temperature and other conditions are known. Theoretically, his formulas take into account all the variables affecting the ultimate results, but a question arises as to whether it is possible to obtain correct results with practically any size of core. Most test cores are made comparatively small to meet the laboratory-equipment limits of capacity and for convenience in handling, especially when a large number of cores is to be tested. Therefore, although the heat-transfer coefficients used for core sizes not differing in height by more than plus or minus 20 to 100 per cent of the test-core height are well within the limits of correctness, when we are called upon to more than treble the height of the test core, we may find that some types will not give the same results as others and as computed.

One of the drawbacks encountered is that, occasionally, the amount of water requisite to handle the heat is unable to pass through the core, thus upsetting the temperature-drop and the ultimate result. Another drawback is that, if the core is very high, we find that the water has suffered a large drop in temperature despite the rapidity of its flow, giving an abnormally cool condition at the bottom of the radiator, from which it is difficult to extract heat. It is apparent that, after we have determined the size of the core, we shall have another task confronting us, that of making it work.

We had an experience with a high airplane-radiator in which we had to divide the core into halves to reduce the water-temperature drop. We obtained the best results by running part of the water through the top half of the core and drawing it out from a tank vertically dividing the core halves; the remainder of the water from the engine was bypassed directly to the lower half of the core and thence it emptied into the bottom tank. In this way we were able to keep the radiator core at the bottom comparatively hot and efficient.

DR. H. C. DICKINSON:—Professor Lockwood's interesting paper gives data on radiator practice that should be of value as a guide to preliminary design. The practicability, however, of depending upon the final figures of 5 cu. in. of radiator per cubic inch of displacement, or 50 cu. in. per hp. is somewhat questionable, because the individual requirements of different engines and car designs may differ from this average value by amounts far too great to be neglected in practice. The author gives,

for instance, extreme figures of 41 and 71 cu. in. per hp., respectively, in two designs that were tested in the laboratory. It seems doubtful whether such differences are due merely to differences of judgment as to satisfactory cooling capacity or to actual differences in the capacities required. Radiators cost too much to be used too generously; on the other hand, overheating is too serious a defect to be tolerated. It seems more probable that some of the following factors are responsible for much of this difference:

(1) Engine design has much to do with the proportion of heat that goes to the exhaust. In fact, this proportion may vary from a minimum of about 60 per cent of the engine power to perhaps 150 per cent of it, at normal loads. While there are, probably, no such large differences between conventional passenger-car engines, the differences are by no means negligible
(2) The hood and the engine mounting determine the freedom of the circulation through the radiator; hence, to a considerable extent, its cooling capacity. In some car designs little provision is made for the exit of the air that enters through the radiator while, in other designs, the passage is not restricted; in still others, louvres in the hood probably produce a certain amount of suction that assists the fan in drawing air through the radiator
(3) Size, speed and design of the cooling-fan are important, as the author mentions, and it is more than likely that differences in the fan alone might modify the radiator requirement considerably

Statistical averages, such as are developed in this paper, are very important. The technique of securing reliable results in this manner is far too little developed and the author deserves much credit for the results he has obtained. There are some problems that can be attacked in no other way, as, for instance, the probable ton-mileage per gallon of fuel in service operation, or the demand of the average driver for any particular feature of car performance, such as acceleration.

N. S. DIAMANT:—Consider a radiator core, 20 in. high, 20 in. wide and 3 in. deep, or 20 x 20 x 3 = 1200 cu. in. Suppose that the total cooling or radiating surface of this core is 100 sq. ft., or 14,400 sq. in. Further, suppose that this core when tested at an air-velocity of 20 m.p.h. and a water-flow of 50 gal. per min., dissipates 1500 B.t.u. per min., with the average water-temperature equal to 190 deg. fahr. and the average air-temperature equal to 90 deg. fahr. Then for this core, the coefficient of heat-transfer will be 1500 divided by 100 sq. ft., divided by 100 deg. fahr. (= 190—90); that is, 0.15 B.t.u. per min. per deg. fahr. per sq. ft., or, 0.15 x 60 = 9.0 B.t.u. per hr. per deg. fahr. per sq. ft. This is the coefficient given by Professor Lockwood in Figs. 2 and 3.

Suppose we want to compare with this radiator another one similar to it in every way except that it is 4 in. deep or 2 in. deep; what water-flow shall we use, 50 gal. per min. as before? Professor Lockwood tells us nothing about this important point. If the water-flow were proportional to the core-depth, then the proper abscissas for the curves given by him would have been gallons per minute per inch of depth of core. In any case, I hope it is clear that test results will be meaningless unless proper consideration is given to the relation between the water-flow and the depth of the core.

Professor Lockwood covers a range of water-flow of 1000 to 4000 lb. per hr. or, in the more usual units, about 17 to 67 lb. per min., or 2 to 8 gal. per min. The curves given in his paper are nearly, or at least roughly, straight lines, and thus, with many others, he seems to think or to give the impression that the cooling-capacity of a core is nearly proportional to the water-flow. This is wrong, as the excellent and creditable work done by the Bureau of Standards under Dr. H. C. Dickinson has shown that this is true for a water-flow up to 2 to 3 gal. per min. per in. of depth of core; but beyond this, increasing the water-flow does not appreciably increase the cooling-capacity of a core. I was rather surprised to find in the paper nothing with reference to this prevalent misunderstanding to which, apparently, the author also subscribes. I have not investigated this question as carefully as has the Bureau of Standards, but I have found in my work also that increasing the water-flow to more than 6 or 9 gal. per min. for a 3-in. core, and in proportion for other depths, does not increase the cooling-capacity or the heat-transfer coefficient of a given core.

Let us return to the example just given and try to compare it with the radiator-cores given by Professor Lockwood. As already stated, this radiator dissipates 1500 B.t.u. per min. per 100-deg. fahr. difference between the average water and air-temperature; that is, 1500 x 60 = 90,000 B.t.u. per hr. per 100 deg. fahr. is its cooling-capacity. Referring to Fig. 4, we find that 90,000 is on the chart; but how can we use Professor Lockwood's chart when we do not know what temperature-difference he has used. We used 100 deg. fahr. (= 190 — 90), but he may have used 100, 105, 95 or what not. The only reference is in the second paragraph under "Cooling Capacity Charts," where it is stated that the "water-temperatures were taken as 200 to 180 for pump-circulation, and 200 to 140 deg. fahr. for thermo-syphon circulation." The air-temperature was assumed to be 80 deg. fahr. Thus, it would appear that, in the chart, reproduced as Fig. 5, the temperature-differences were taken as 190 — 80 = 110 deg. fahr., and [(200 + 140)/2)] — 80 = 170 — 80 = 90 deg. fahr. for pump and thermo-syphon systems respectively.

Again, before we could use Fig. 4, or in fact before Fig. 4 can convey any intelligent meaning, it will be necessary that we know the size of the radiators. In the example given above, I took a core 20 in. high and 20 in. wide; in all my special testing work for several years I have adopted a standard core, 17 x 17 in. in size, because this is nearly equal to 2 sq. ft. of frontal area. If Professor Lockwood had given us the size of the radiators, including their depth, or if he had expressed cooling-capacity in British thermal units per minute per square foot of frontal area per certain number of degrees of temperature-difference between the water and the air; or if he had done anything equivalent, then Figs. 4 and 5 would have meant something. It is not possible to compare radiators on the basis of British thermal units per hour without giving the above information in one form or another.

Another point worthy of attention is the method of expressing airflow. Consider the same example given above and suppose that the air-velocity, as measured a few inches in front of the radiator, at a section 20 x 20 in., is 20 m.p.h. Assume that the airflow is fairly uniform, or that 20 m.p.h. is the average velocity. Then 20 x 880 x [(20 x20) / 144] x 0.075 =4890 x 0.075 =367 lb. per min. of airflow at the average temperature and barometric pressure. It has been found independently by the Bureau of Standards, by myself and by others that heat-transfer depends upon the mass-flow of air; the Bureau of Standards in its work has expressed this mass-flow in pounds per second per square foot of frontal area. This is the correct way to express mass-flow; however, in all my work I always have expressed it in miles

per hour, which is defined as explained above, and is measured in front of the radiator. This velocity in miles per hour is proportional to the mass-flow and, if desired, can be corrected for pressure, temperature and humidity. According to Professor Lockwood, we shall have to express it as miles per hour as above, divided by the free area, in per cent. I take it that Fig. 2 was made on this basis, which is the wrong basis. Consider two radiators that dissipate 1500 B.t.u. per min. at 20 m.p.h., or 367 lb. per min. of airflow through a 20 x 20-in. section, or (367 x 144)/(20 x 20) = 132 lb. per min. per sq. ft. of frontal area. Suppose one core has a free area of 65 per cent and the other a free area of 75 per cent. I would say that both radiators dissipate the same amount of heat at 20 m.p.h., or at a mass-flow of 367 lb. per min. of air. The air-velocity, however, through these cores will be 20/0.65 = 30.8 m.p.h. and 20/0.75 = 26.6 m.p.h., according to Professor Lockwood, and are not at all comparable. Thus, his test results and mine would not agree at all and, in fact, he might easily reverse my test results.

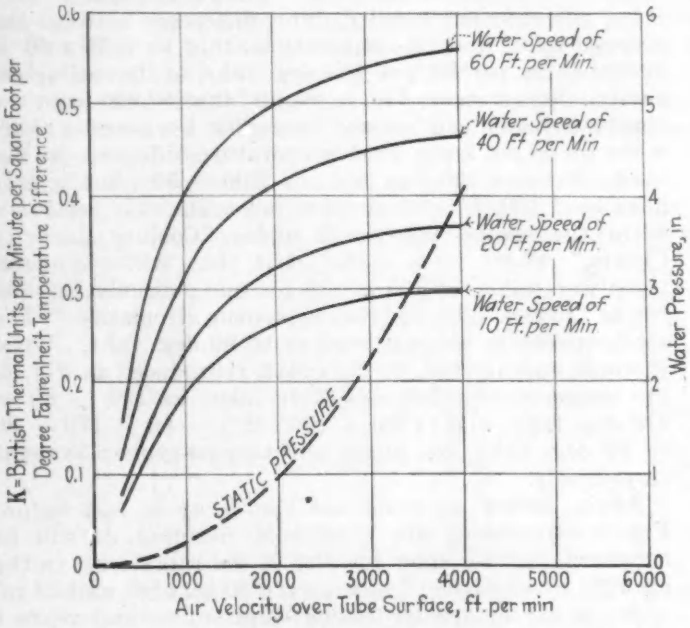

FIG. 8—HEAT-CONVECTION COEFFICIENT CURVES FOR A SOLDERLESS RADIATOR

I have gone into these matters in some detail because we have not had many papers on the performance of automobile radiators and I believe it is very important that we should get started right, particularly when this is not much harder to do than getting started wrong. We would not think for a moment of comparing knowingly two temperatures, one expressed in degrees fahrenheit and the other in degrees centigrade. This, however, is exactly what we are doing when we attempt to compare radiators on the basis of airflow through the core, or in British thermal units per hour, without stating the temperature-difference between the water and the air and the like. In these latter points, no doubt, Figs. 3 and 4 are correct, but they do not state all the facts. As to Fig. 2, as already explained, there is a fundamental difference in our ways of comparing radiators. We have first, to know what the difference is and, second, to clear it up.

G. A. FOISY:—Professor Lockwood has brought out some points to which I must take exception. One of these is the statement that 51 cu. in. of core is required to cool an engine properly by the thermo-syphon system. This is not borne out by actual practice in the installation of cores made up of individual seamless copper tubes. In figuring the surface required to cool an engine properly with the thermo-syphon system, I have used a factor for cubic contents per horsepower that never exceeds 45. Our cores are giving extremely gratifying results in the cooling of a typical car of this class, namely, the Ford, by using a factor of 43 cu. in. per hp. These figures are based on the horsepower developed by the engine at a road speed of 25 m.p.h.; in the above case, very close to 15.

As I understand Professor Lockwood's charts, Figs. 3 and 4, he bases his calculations on the assumption, which is probably true for certain types of core, that car-speeds of 22 and 44 m.p.h. correspond to air-velocities through the core of 1500 and 3000 ft. per min., respectively. Professor Lockwood probably assumes that these figures are approximately correct for all types of core for the reason that, in Table 1, he finds that the free areas of all types are approximately equal. We have found in testing various cores that although the free area of any core, especially one of the fin-and-tube type, or of a certain ribbon cellular type, might be close to that of an individual tube type, yet the resistance to airflow of the first two types greatly exceeds that of the last. This is explained, to my mind, only by the fact that the eddy currents set up in the first two create an extra high resistance that we do not encounter in our core. Because of the lower resistance to airflow of our core, we are able to use a lower factor, or a higher heat-transfer coefficient, than is ordinarily used in common practice.

I believe that Professor Lockwood also makes the statement that the radiating surface might be considered proportional to the cubic displacement of an engine, or in other words, to its nominal horsepower. If this is so, I have never been able to explain satisfactorily why it is that we can cool such engines as the Ford, the Maxwell and the Chevrolet properly, all of which are syphoned by using a factor of 1¾ sq. ft. of radiating-surface per nominal horsepower, yet we find it necessary to use 2¼ sq. ft. per hp., or more, when figuring other cores that have a regular pump system. Perhaps it may be on account of the obstruction to the airflow in the large cores that is caused by the smaller clearance between the engine and its accessories and the hood, or louvres; but of this point I am not certain.

In conclusion, has Professor Lockwood ever reduced his calculations to the form of British thermal units dissipated per pound of core? To me this seems to be the logical procedure for, while it is admitted that a larger amount of radiating surface can be created in any core by the addition of various fins, inserts and the like, yet the type of core that will emerge superior will be represented by the core that can dissipate the largest number of heat units with the least weight.

L. C. JOSEPHS, JR.:—Professor Lockwood's paper is of particular interest to anyone connected with the motor-truck industry, as it will be a long time, if ever, before motor-truck builders will be able to get away from water-cooling. Laboratory tests of radiators are of considerable value, but great care must be taken in using these results to determine the probable performance of some new design. At the plant with which I am connected considerable work has been done along these lines. Many tests were made on small and on full-size sections of core mounted in a wind-tunnel, to determine the relative efficiency of the various designs of core; and a large amount of interesting data was found with regard to heat-convection coefficients. Figs. 8 to 10 show some of the results of this work.

The several points of view from which to judge the

efficiency of an automobile radiator in regard to the amount of heat removed are (a), per cubic foot occupied by the cooling system; (b), per horsepower consumed in air and water circulation; and (c), per pound of core material. The same type of core will not be the best when viewed from all three angles. When a cooling-system of a definite design is to be considered, a compromise among these three points of view will be necessary.

For this reason, we discontinued wind-tunnel tests some 2 years ago and have made all the tests since then on a test-stand on which a complete cooling-system is set up, exactly as it would be on a motor truck. The power is absorbed in a dynamometer and complete data can be secured as to temperature, water-circulation rate, air-circulation and the like. The test is made in a closed compartment so that any desired room-temperature can be secured, even as high as 135 deg. fahr., which corresponds to the conditions in the Imperial Valley in California. It is possible with this set-up to test not only radiator cores, as a part of a cooling-system, but the equally important items of pumps, fans, nature of the flow in the water-jackets, restrictions in the outlet of the air and many other seemingly minor points that actually have a great effect on a cooling-system. As a result of tests of this kind, our company has developed a very simple cooling-system recently, which, without boiling, will take care of the heat losses of the engine continuously at full load at any speed, at a still-air temperature from 100 to 110 deg. fahr.

In describing the air-cooling system developed by his company, C. P. Grimes made some similar claims, qualifying them by stating that a quantity of air should be blowing against the crankcase. It is interesting also to note that in the system that we have recently developed we have secured an air-temperature rise as great as 60 per cent of the air-water temperature-difference, which is equal to the results claimed by Mr. Grimes.

PROFESSOR LOCKWOOD:—Mr. Diamant's comments and criticisms are interesting, if only to prove that radiator testing is still an unorganized science, where fellow workers have difficulty in understanding each other. It would be a happy outcome of this discussion if a better agreement could be reached on some of the fundamentals of the subject.

Let us look first at Mr. Diamant's example of a core 20 x 20 x 3 in.; water-flow, 50 gal. per min.; air velocity 20 m.p.h.; and radiating surface 100 sq. ft. This core is

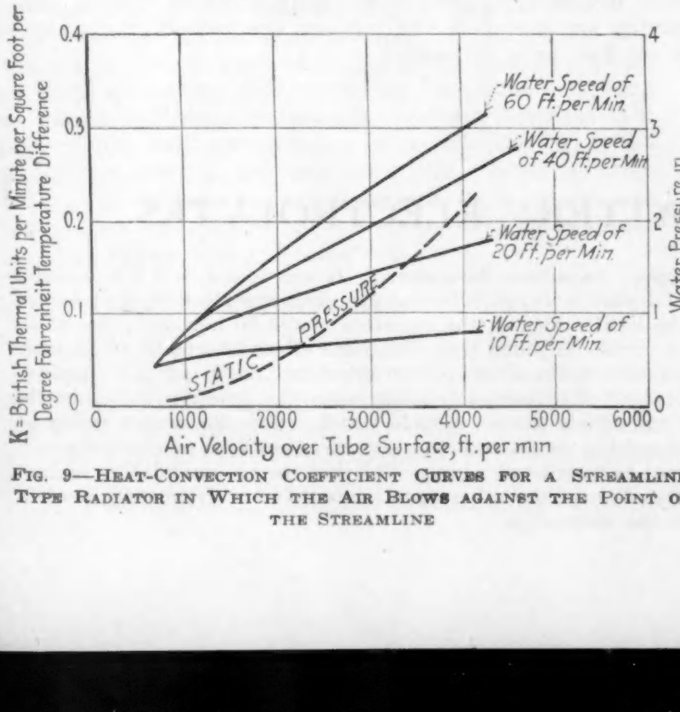

FIG. 9—HEAT-CONVECTION COEFFICIENT CURVES FOR A STREAMLINE TYPE RADIATOR IN WHICH THE AIR BLOWS AGAINST THE POINT OF THE STREAMLINE

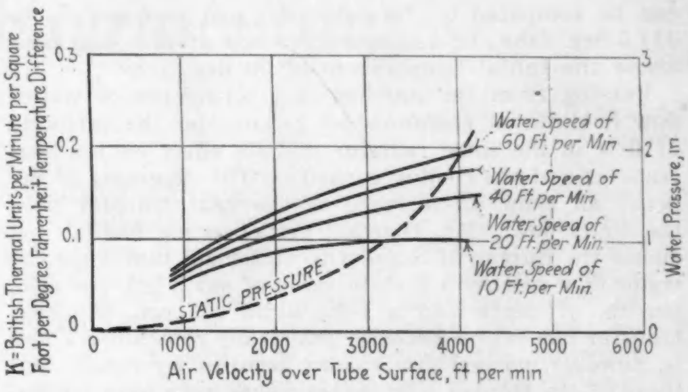

FIG. 10—HEAT-CONVECTION COEFFICIENT CURVES FOR A STREAMLINE TYPE RADIATOR IN WHICH THE AIR BLOWS AGAINST THE BLUNT END OF THE STREAMLINE

supposed to dissipate 1500 B.t.u. per min. with a mean water-temperature of 190 deg. fahr. and mean air-temperature of 90 deg. fahr., where the heat-transfer coefficient is found to be 9.0 B.t.u. per hr. per sq. ft. per deg. fahr.

To compare this radiator with another one similar to it in every way except that the depth is changed to 4 in., it will be necessary to make three new assumptions. First, the surface must be increased in proportion to the depth, or in the ratio of 4 to 3. Second, the water-flow must be increased to make the water temperature drop the same in both cores. Third, the heat-transfer coefficient will be slightly less for the deeper core. The claim that my paper gives no directions for water-flow in this case is not well taken, since the paragraph on Limiting Values of Core Depths states clearly that the water-flow is to be changed to produce the same temperature drop.

In applying formula (7) to this case, it is not necessary to know the rate of water-flow, as the temperature drop gives the same information. To illustrate this point and incidentally to show the utility of formula (7), the heat radiation for the 4-in. core will be computed with all other conditions unchanged. The surface will be increased from 100.0 to 133.3 sq. ft. The water-temperature drop will be 90,000 divided by 50 x 8 x 60, or 3.75 deg. fahr. The heat-transfer coefficient will be reduced from 9.0 to 8.5, an arbitrary figure in the lack of experimental data on this point. The air-flow will be computed from the 3-in. core, as this value must hold for the 4-in. core also. It will be assumed that the air velocity of 25 m.p.h. relates to the air approaching the radiator being reduced to 65 per cent of the original velocity when passing through the free-air area. With this velocity and a free-air area that is 70 per cent of the frontal area, the air-flow by formula (2) is found to be 9500 lb. per hr. The temperature of the air approaching the radiator will be assumed as the same for both. The air-temperature rise for the 3-in. core is 90,000 divided by 0.24 x 9500, or 39.5 deg. fahr. Accordingly, if the mean temperature is 90 deg. fahr., the entering temperature must be 90—19.7, or practically 70 deg. fahr.

Substituting the values in formula (7), the heat radiated is found to be 108,000 B.t.u. per hr. for the 4-in. core. Special attention is called to the facility with which this problem is solved by formula (7). The rate of water-flow was not required in formula (7), but it can now be computed by formula (3) as 29,000 lb. per hr., or 60 gal. per min., as compared with 50 gal. per min. for the 3-in. core. The final air-temperature

can be computed by formula (4), and is found to be 117.5 deg. fahr., or a temperature rise of 47.5 deg. fahr. above the initial temperature of 70 deg. fahr.

Passing from the problem just considered of water-flow in different radiators, let us consider the variation of flow in the same radiator and its effect on the heat transfer and the cooling capacity. The diagrams of my paper all show an increase of the heat transfer with the water-flow. Mr. Diamant criticises my finding and quotes the Bureau of Standards' statement that when the water-flow reaches a certain value of say 3 gal. per min. per in. of depth and a 1-ft. width of core, the heat transfer per degree becomes practically constant. There is, however, no real discrepancy between my results and those of the Bureau. My experiments have been carried on over the range of water-flow from 0.5 to 2.0 gal. per min. per in. of depth and a 1-ft. width of core. Over this range the heat transfer varies with the water-flow, as all experimenters know. These velocities were chosen as covering the ground between thermo-syphon on the one hand, and pump circulation on the other.

The falling off of heat transfer at low water-velocities has been charged to a lack of turbulence in the stream. A more natural explanation is that, at low velocities, the water chooses certain channels or tubes that offer least resistance, while the remaining channels have practically no circulation, hence rendering parts of the core inoperative, or nearly so.

In defense of Fig. 4, that Mr. Diamant has criticised, it may be sufficient to say that this diagram was prepared solely to compare different types of core with each other, to draw conclusions as to their value for cooling. For that reason the size of core used in the comparison was not given. On the other hand, Fig. 5 is intended to apply to one kind of core of any frontal area or depth within the limits stated. This diagram can be prepared for a given set of conditions, which are prescribed in advance. If different conditions are prescribed, a new diagram must be prepared. The conditions for Fig. 5 were a constant car-speed of 25 m.p.h., approaching air at 80 deg. fahr. water-circulation sufficient to make a temperature drop of from 200 to 180 deg. fahr. for all sizes of core, and a good type of ribbon cellular core. The required water-flow for each core is given at the bottom of the chart in two different units. In attempting to solve the problem proposed by Mr. Diamant by this chart, the conditions differ so widely that the chart cannot be used.

In the matter of measuring air-flow, Mr. Diamant and I are far apart; indeed, we appear to have little common ground to stand on. For example, he refers to an hypothetical case of a 20 x 20-in. core with a given air velocity in front, for which he figures a mass-flow of 367 lb. per min. I have figured the air flow for the same data and arrive at the result of 170 lb. per min. Apparently, we are computing something different and are calling it by the same name. Mr. Diamant is plainly unable to understand my method of handling air velocity, and I confess to inability to understand how he uses mass-flow in his computations.

It is interesting to learn from Mr. Foisy that manufacturers of air-tube cellular-cores are obtaining satisfactory cooling with core volumes of 43 cu. in. per hp. at 25 m.p.h., and thermo-syphon circulation. Pump circulation is always assumed to give better cooling than thermo-syphon, yet the paradoxical fact exists that some engines cool better with thermo-syphon than others with a pump. The reason is to be found among the several things mentioned by Mr. Foisy, such as influence of the engine fan and the restrictions in the outlet of the air from under the hood. I have not made the comparison suggested by Mr. Foisy, of cooling capacity based on the weight of core used. This comparison is closely bound up with another of the same kind, the cooling capacity per cost of core.

Mr. Josephs has referred to a practical method of testing radiators used by his company, employing apparatus exactly equivalent to the truck on which the radiator will be used. As no mention was made of a separate blower, I assume that the engine fan circulated the air for cooling. We have made a few experiments on the rear-wheel dynamometer of a similar kind. With the rear wheels resting on the drums, the engine was run with a gradually increasing load until the radiator boiled, with no air cooling except that given by the fan. At the ordinary room temperature, the Ford radiator boiled with only 4 hp. on the engine. Under the same conditions, a Willys-Knight radiator cooled the engine when developing 28 hp. with no evidence of excessive heating. Both engines had thermo-syphon circulation.

Chairman Litle has mentioned the problem of steam cooling and how the radiator is dealt with in this case. It is safe to say that the heat dissipation with steam in the radiator is exactly similar to that for water. The steam-heated surfaces will be at a higher temperature than the water-heated surfaces; hence, they are more effective for heat removal. The thermal formulas for cooling capacity apply equally to water or steam.

Mr. Cucurello raises a point in radiator construction that is rarely mentioned, the limiting height of the core. He cites the case of an airplane radiator that was divided into two parts, with a water header supplying hot water to the top and the bottom parts, with a marked gain in cooling.

IMPURITIES IN STORAGE-BATTERY ELECTROLYTES

THE importance of obtaining information concerning the action of impurities in storage-battery electrolytes arises from the detrimental effects that many of them produce on the operating characteristics and life of the storage-battery. Such information is necessary as a basis for the preparation of specifications covering sulphuric acid for use in batteries. A new method of measuring the rate of sulphation of storage-battery plates was recently devised at the Bureau of Standards. The same method and apparatus have been employed in the present investigation with some modifications, and the effects of small amounts of iron, manganese, platinum and copper have been determined. It was found that the presence of 1 part in 10,000,000 of platinum in the electrolyte increases the local action at the negative plates 50 per cent; the effect of copper is much less, while the effect of iron is of unusual interest because of its accelerating action at the negative plates. Manganese deposits upon the positive plates in the form of manganese dioxide which covers the active material, closes the pores and causes a large amount of charging current to be wasted as gas. Work is being extended to include the effect of the other impurities that are frequently present in the electrolyte.

Two Kinds of Engineering

By F. E. Moskovics[1] Indiana Section Paper

MR. MOSKOVICS pays tribute to the motor-car engineer as being one of the great benefactors of humanity, and believes that two definite kinds of engineering, theoretical and empirical, are essential in designing, developing and building the truly great motor-car. He enlarges upon the requirements of empirical engineering and emphasizes the necessity for it, since empiricism is founded upon fact, experiment and experience, the last being inclusive of the essential element, time, without which no car can be proved great.

The service department is stated to be the only department in the automotive industry that can digest the empirical data that are obtainable from the actual experience of the public while operating cars and present it in an understandable form to the engineer, the agent being the service-manager, and a plea is made that he function as the eyes and ears of the automotive engineer.

I YIELD to no man in my conception of the magnitude and importance of the position of the engineer in our industry. What he has accomplished in the past, almost unaided by any historical data, is but a greater tribute to his genius and sheer ability. I believe that the motor-car engineer has been one of the greatest benefactors of humanity in general, and of our own generation in particular. Our present-day motor-car, with its combination of excellence and low price, is a tribute to him. The rise of the engineer as a leader in thought and development in all social endeavors has been extremely rapid, and it has come through sheer proof of his ability to analyze, deduce and conclude, and then put his findings into action to express energy in terms of fact.

The technical man alone is responsible for this early-stage development of the modern motor-car as a transportation unit. After all, this is only an elementary stage; the stage wherein it has been proved definitely that motor-cars can be made to operate over a fairly wide range of conditions and to perform their functions with a reasonable degree of consistency and of comfort to their users. The industry is rapidly approaching, if, indeed, it has not already reached, a more mature stage. And especially is this true on the mechanical side.

The reaping of the best rewards of this stage will require a different kind of engineering, and I have no hesitancy in saying that anything less than the very best results will reap no rewards. So, any remarks that follow, I beg will not be taken as a reflection upon the accomplishments of the engineer, but rather as suggestions as to how he can approach more easily and accomplish a little more fully the more wonderful things that open before him for tomorrow.

Future Engineering Accomplishment

As I view the mechanical structure of our industry, to design, develop and build the truly great motor-car, two definite kinds of engineering are essential. Nay, I would say absolutely imperative. The first I shall call technical. Theoretical, if you please. Here the technically educated and trained engineer is supreme and alone. Here the technician, the physicist, the metallurgist, the mathematician, the chemist, combine to design the coming car theoretically. But, after all is said and done, a car designed by the best of these elements is only an unbaked shell. No truly great motor-car was ever developed only on paper. I even venture the statement that no new engine was ever great during the first years of its existence. So, the technical man may design and experiment. He may drive and experiment with engines to his heart's content. But, until the car has gone through the varying crucible of the untrained, untried public's hands, it will never be really great. Theoretically, it may have every element of soundness. Metallurgically, it may be ideal. But until it has gone throught the millions of miles in the hands of the more or less unskilled Mr. and Mrs. General Public, it is untried and unfinished.

And here comes in my second kind of engineering, which I will call, for want of a better name, empirical engineering. The definition of an empiricism is a conclusion founded on fact, on experiment, on experience. The engineer must put his motor-car through the experiments and experience in the hands of Mr. Everybody; and, add to that, the always essential element without which no car can be proved great, time.

Under this form of engineering, consideration must be given to every possible factor; varying climatic and road conditions over the entire area in which the car is to be used. I submit to you that the confines of our own Country plus Canada offer in themselves a most fruitful field of study on this one subject. In the matter of the effect of altitude on both mixtures and pressures; the type of owner whom your particular car appeals to; the chauffeur in the case of a car of the higher grade; the maximum abuse the car can encounter, which will vary with its flexibility and speed; fuels, good, bad and indifferent; lubricants, their uses and abuses. After taking into consideration only these few points, without endeavoring to cover the field, deliberate for a moment upon maximum possible stresses the car can be subjected to by the greatest combination of all these elements. Empirical engineering must watch and study the cars in the hands and haunts of those great bosses of all of us, Mr. and Mrs. Ultimate Consumer. It must see, hear and understand and, when all the evidence is at hand, act intelligently.

Data for Empirical Engineering

Now the true data for this second kind of engineering cannot be supplied by the engineering department, due to the inherent limitations of its own peculiarities, its forms of organization and the fact that, after all, the engineer cannot make himself omniscient and cover the entire universe. Moreover, the engineer is entirely too personal in viewing the child of his brain, and cannot look fairly on the actions and results of that child when it gets out into the wide, cruel world.

In the modern motor-car factory, there is only one department that can digest this information properly and present it in understandable form to the engineer, the service department. I will not attempt here to analyze the meaning of service, but I will say that in the

[1] M.S.A.E.—Vice-president, Nordyke & Marmon Co., Inc., Indianapolis.

functioning of the present-day motor-car factory, the service department occupies a most important role. I place at the top of the list of the things it must do, the responsibility of presenting to the engineering department in a sound and unbiased way a cold, analytical study of exactly what the product is doing in every part of the Country in the hands of the owner, day-and-night, during the four seasons of the year. For the purpose of this paper, I will touch only that phase of the work of the service manager.

The Service Manager

He is the one whose duty it is to be in touch with the dealer's service departments throughout the Country. He it is who receives the individual complaints from the owners who come into contact with the well-equipped and poorly equipped service-stations. The value of his work is measured by the accuracy and clearness with which he tabulates and presents to the engineering department the data he collects. He is charged with the grave responsibility of portraying just what the product is doing. He must interpret the public's approval or disapproval of the mechanical operation of the car; and, without abuse or personal rancor, distill the seething mass of information he secures into intelligible, usable data. This is a mighty problem, a great duty. It is second only in importance to the design of the car itself.

You will remember that there has always been grave argument as to who accomplished the greatest good for this Country; George Washington, the founder, the beginner, or Abraham Lincoln, the savior. I view the relations of the engineer and the service department in much the same light. The service manager must be diplomatic enough in the moments of stress, when a particular thing is going "bad," to present the case to the engineering department in purely mechanical terms. He can venture an opinion as to a cure, especially if it is the result of contact with a number of service-men. He can even arrange matters so that trusted service-men who come into direct contact with the owners will be brought into the factory for a confidential conference. All this must be done without casting any reflections on the engineering department, without any rancor or feeling. Indeed, it calls for a two-fold ability. The service department that does this as it can be done is invaluable to the engineering department, and no great engineer will ever refuse to welcome and use information obtained in this way.

If the service department functions in this manner, it will be the eyes and ears of the engineer. It will inform him as to where throughout the Country casing-head fuels are being used; where engine pounds are developed due to blended fuels; where crankcase-oil dilution and its attendant difficulties are most prevalent. The service department that does that to the greatest advantage will, in my opinion, perform its other more routine duties with little effort.

In a properly organized company, the chief executive will see that the service department has a voice in bringing these topics before a properly constituted authority, preferably the engineer. If, after enough repetitions have occurred to constitute a history, the mistakes have not been rectified, a clear channel should be established through which the service manager can present the difficulties to a higher authority. The right kind of service manager does not, I believe, need this channel, but will force the matter to an early conclusion.

Transportation Is the Commodity Sold

After all is said and done, we are selling transportation. We are not selling a mass of steel, aluminum, rubber, glass and leather called a motor-car. That is not what we are designing. It is the ability of this impersonal thing to perform acts of transportation that is important. And the service manager is the one man in the organization who can translate in substantial form what the engineer should know, whether the mechanism is delivering the form of transportation that our sales departments glibly promised to the ultimate consumer.

As the motor-car approaches more nearly the stage of mechanical perfection, this work becomes more and more important, because our public will become more and more critical; the little things we overlooked before become more and more aggravating, and can be eliminated only by the closest attention to detail and ascertaining the real results in the owner's hands. It is the irrefutability of basic facts that gives the modern engineer leadership.

ALUMINUM-ALLOY PISTONS

SINCE the introduction of aluminum alloys for pistons some 9 years ago, the two chief difficulties have been the development of a suitable alloy and a satisfactory design. The material must, of course, resist such shocks as are met with in internal-combustion engines and possess high thermal conductivity. The coefficient of thermal expansion must be comparable with that of iron; otherwise piston-slap would occur until the engine got warmed-up. The author believes that the temperature such pistons experience in practice must often be well above the 250 deg. cent. (482 deg. fahr.) suggested by another authority and bases his opinion on the observed changes in the internal structure.

The National Physical Laboratory advocates for pistons an aluminum-alloy with 4.0 per cent copper, 2.0 per cent nickel and 1.5 per cent manganese. This in 1-in. diameter chill-cast bars gave an ultimate stress of 482 deg. fahr. of about 12 tons per sq. in., compared with 7 tons for a 1-per cent copper alloy that was used to a very great extent some few years ago.

Cases occurring of burnt aluminum pistons show the upper side of the piston-head pitted like a sand-eaten casting, probably due to either faulty design or defective lubrication. Metallurgically, the fault appears to lie with the fusion and the migration of the copper-aluminum eutectic with the ultimate disintegration of the whole metal. To prevent the occurrence of large connected masses of copper-aluminum eutectic, the casting temperature must be kept as low as possible. Experiments show that the clearance should exceed by 50 per cent that of a cast-iron piston. The cast pistons are subjected to a temperature of about 716 deg. fahr. for at least 6 hr., but preferably 24, in order to bring the copper-aluminum compound, $CuAl_3$, into solid solution.—Extract from *The Metal Industry*.

Testing Materials for Automotive Parts[1]

By R. J. Allen[2] *Illustrated with* Photographs

IN the production of any complicated machine such as the automobile considerable attention is paid to the dimensional inspection of all parts while but little attention, comparatively, is paid to the inspection of the quality of the material used other than to see that its surface is of the desired hardness and free from seams or cracks. The reason for this is two-fold: First, inaccurately machined parts, aside from being non-interchangeable, cause trouble in assembly and also prevent the smooth operation demanded by sales, while unsound or improperly heat-treated parts do not, in most cases, cause trouble until after they have been in service for some time; second, instruments for checking the dimensions of any machined surface have been developed to a much greater extent than have those for peering into the interior of metals, so that the inspection of the latter is necessarily more troublesome and uncertain.

The magnetic analysis and the X-ray offer possibilities for the future, but at present, aside from the simple surface-hardness test, all forms of physical tests are more or less destructive in nature and hence cannot be applied readily to the part intended for service. The usual practice therefore is to select representative samples from the lot of material received from the mill, make tests on these and assume the remainder of the stock to be of the same nature. Material accepted by these tests is then passed for use to be worked into forgings or machined parts. If the tests are numerous enough and the results uniformly good, it is perhaps logical to assume that the material is satisfactory, but subsequent to these tests carelessness on the part of the forge-man through improper hammering or excessive overheating, or on the part of the heat-treater may leave some of the pieces in such condition, not revealed by the final Brinell hardness test, that ultimate failure in service must result. The representative tests on the original stock therefore cannot be regarded as a true criterion of the finished part.

Prolongation Tests

To the company whose reputation is built on the continuity of service of each individual car over long periods of time without replacement or adjustment because of breakage or excessive wear it is essential that the soundness of each important or highly-stressed part be assured before it is passed for service. On vital parts, such as steering members, where failure may result in serious accident, this is doubly important. With present facilities the only reliable and at the same time practical way of obtaining this assurance is by the individual fracture-test. This, while not made on the material actually used in the part, can be carried so close to the actual part, with the aid of a properly attached prolongation, that the possibility of variation is indeed slight.

Fig. 1 shows a few of the parts of the Rolls-Royce chassis provided with test prolongations. These extensions are left undisturbed until the pieces have passed all stages of heat-treatment and final hardness inspection. Then they are nicked, broken off and examined. It will be noted that the prolongations are located so that when fractured they expose a transverse section of the central portion of the metal being used. Attention is called to the ball-end for the steering piece, a part machined from bar stock, with its double prolongation. The upper one reveals the depth and refinement of case, when fractured; the lower one, bent through an angle of 90 deg., reveals the ductility of the core.

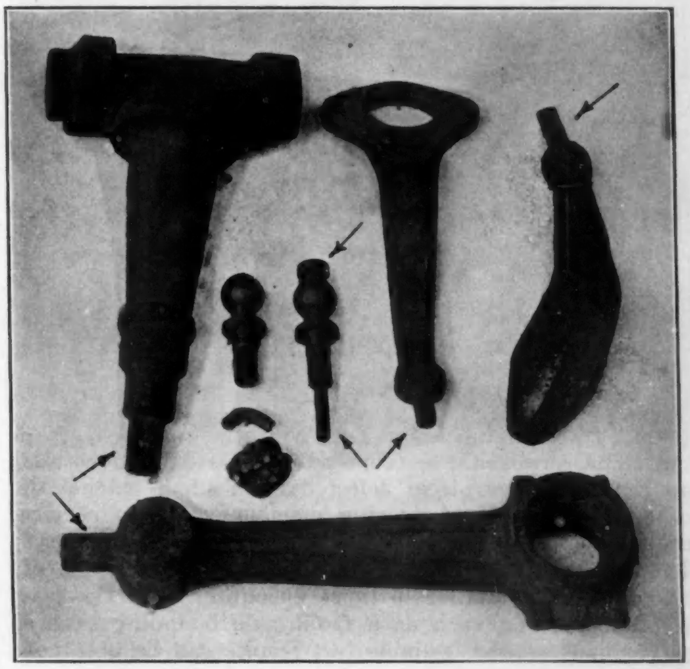

Fig. 1—Method of Attaching Test Prolongations, Indicated by Arrows, to Highly Stressed Parts

From the appearance of the fracture one can tell whether the material is sound and in the structural condition desired, and also predict with considerable accuracy the results that would be obtained on a physical test. The prediction as to physical results, however, like the file test for hardness or the color observation for temperature, is not absolute, and recourse must be had frequently to some standard form of physical test, just as the feel of the file must be checked against the scleroscope and the color against the pyrometer.

Dynamic Tests

Excluding the hardness test, which is non-destructive, the forms of physical test against which fracture may be checked, vary. The tensile test is undoubtedly fundamental, but its static form of loading does not approximate with sufficient accuracy the condition under which most material is stressed in service; other forms of test, dynamic in nature, have therefore been devised to augment the tensile, each intended to check some particular condition or form of service stress. Among these may be mentioned the Izod impact, Upton-Lewis alternate-stress and the Stanton alternate-impact.

The Stanton machine, of English origin and until very recently relatively unknown in this country, has been used with satisfactory results by the company with which

[1] From an address delivered before the Providence, R. I., chapter of the American Society for Steel Treating.

[2] Metallurgist, Rolls-Royce of America, Inc., Springfield, Mass.

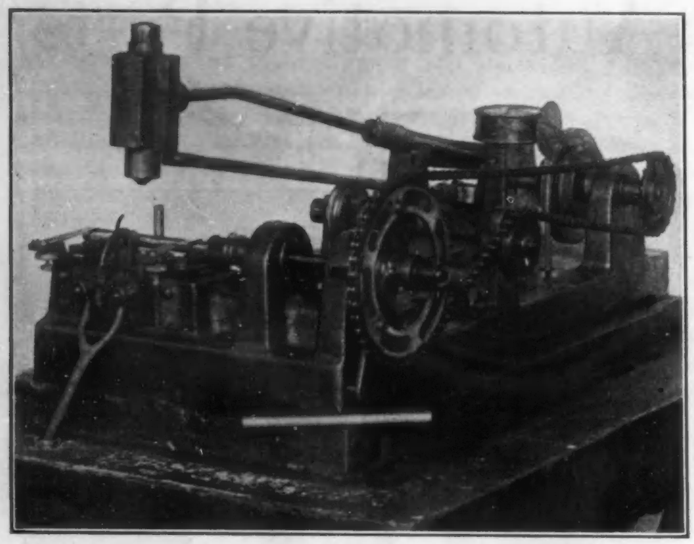

FIG. 2—THE STANTON ALTERNATE-IMPACT TESTING MACHINE

I am connected in conjunction with the tensile test on individual crankshafts, front axles, rear-axle tubes and on representative pieces selected from small batches of other parts, such as steering members, that in service are subjected to impact and reversed forms of stress. The machine is unique in that, first, the conditions of test are nearly similar to those encountered by the material in service, such as a front axle bounding over a rutty road; second, reliable test-results can be obtained in the short time of about 1 hr.; and, lastly, results can be duplicated with considerable accuracy. It is interesting to note that the principle of the test is being copied by some of the American instrument manufacturers; the machine is being offered for use in slightly modified forms. The machine is illustrated in Fig. 2.

STANTON MACHINE

The test piece, which is ½ in. in diameter, has a 0.05 in. square groove cut around its periphery near the center to localize the stresses. The piece, placed on two anvil supports 4½ in. apart, is set with the groove midway between the supports and directly under the 4-lb. hammer. The hammer is raised by a cam to the desired height, usually 2 in., from which it falls by gravitation onto the test-piece. Each time the hammer is elevated, which is at the rate of 90 times per min., the test-piece is rotated one-half turn so that successive blows are delivered on opposite sides. Failure, in the form of a fatigue, progresses from the opposite sides toward the center until finally the section paralleling a diameter becomes so reduced that it snaps off in tension. An automatic switch stops the machine when failure occurs and a recorder totals the number of blows. The number of blows obtained on the piece under test is compared with those previously obtained on other pieces of the same type of material which have stood up well in service, and judged accordingly.

Experience has shown that by purchasing steel from a reliable source where every precaution is taken to produce sound stock, by making suitable physical tests on representative specimens after forging and heat-treating, by Brinelling each piece and finally reading the individual test-fracture, one can hold failures to a negligible quantity.

THE WAR ON THE LOCOMOTIVE

IN view of the complaints now being made by the railroad officials that the motor vehicles are robbing their lines of a large proportion of the short-haul freight and passenger traffic, the following extracts from an article with the above title that appeared in *McClure's Magazine* for March, 1903, are of interest:

> The number of passengers carried on American steam railroads has fallen off by over 12,000,000 in 7 years. The same explanation is implied in the curious circumstance that people seem to be traveling longer distances. The average passenger haul in 1892 was 23.59 miles; in 1900 it was 27.90 miles.
>
> Of course people are not really traveling less frequently than they used to, nor are they journeying longer distances. More passengers by hundreds of millions are traveling than ever before, but the steam railroads are not carrying the increase. The growth in the length of the average passenger haul on those roads means that they are steadily losing the short-haul business, which a younger and more vigorous rival is claiming for its own.
>
> Inch by inch the field is contested, and slowly, sullenly, the locomotive is giving way before the insistent trolley. A dozen years ago it was only the car horse and the cable in the towns that were threatened by electric traction. Then the trolley poked an inquiring tentacle over the city limits into the suburbs. The results were satisfactory, and swiftly the electric lines flung their spider filaments from town to town, until now great sections of the country are cobwebbed with them. The trolley map of eastern Massachusetts looks as complete as the steam railroad map. If you have a little time to spare you can go on an electric car to almost any part of southern New England that you could reach by a locomotive, and to a good many parts that you could not.
>
> In Massachusetts last year four times as many passengers were carried by electric cars as on the steam roads. Of course that was due chiefly to the dense city traffic, but still the city street-car systems were pretty complete 7 years ago and the trolley passenger business has doubled since that time, while the steam passenger business has actually declined. The electric mileage of the State has increased by from 9 to 18 per cent every year since 1894. In 1901 the increase was 242.7 miles. In the same year the length of steam lines was reduced by 1.39 miles.

The paragraphs quoted above show that to a certain extent history is now repeating itself. The trolley systems of 20 years ago have not only been superseded as a rival of the railroads by the motorbus as a means of passenger transportation but are themselves in their turn feeling the ever-increasing competition of the newer vehicle that has invaded the field in which formerly they were supreme.

Vol. XIII July, 1923 No. 1

Shoeing a Car with Low-Pressure Air

By J. E. HALE[1]

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DIAGRAMS

THE author describes the results of a deliberate attempt to make motor vehicles ride on air that is at a low pressure, through the usage of an air-cushion tire having greater carcass flexibility than is usual and by enlarging the size of the tire section so as to provide a greater area of contact between the tire and the pavement. The goal tried for was to increase the area of contact sufficiently so that air pressures ranging from 20 to 35 lb. per sq. in. could be employed in actual practice.

Fundamental conditions are considered first, followed by statements as to what advantages the air-cushion tires containing air at low pressure give to a car. The effects on car operation are presented at some length, inclusive of considerations regarding car speed, steering ability, front-wheel shimmy, traction, braking control, blow-outs, side-sway, and other factors of influence.

Durability and tire cost are treated in some detail, specific applications of air-cushion tires to automobiles are considered and a discussion of their desirability is invited. In conclusion, recommendations are made for a new tire-size nomenclature, in regard to oversizing and to tire-deflection limitation; and specific tire-size recommendations for air-cushion tires on stated makes of car are advocated in the Appendix and tabulated. Numerous illustrations and diagrams accompany the paper.

THERE are good reasons for believing that the automobile industry is on the threshold of the third great development in pneumatic-tire construction. The motor-car industry grew and expanded through its development years on square-woven fabric-tires of rather small cross-section. The art of building tires was new and our best constructions in those days were the small, stiff carcasses that naturally called for high air-pressures. Their shortcomings are too well remembered to need recalling, to say nothing of the range of sizes and the struggle for ascendancy between clinchers and straight-sides.

The employment of cord fabric in carcass construction was the second step in advance in pneumatic-tire structure. By virtue of this change in carcass construction, together with the realization of the importance of more ample sections, tire mileages were increased greatly, with a corresponding reduction in cost. There was not only a mileage increase, but the tires were much more reliable and not subject to such exasperating failures. It is possible that, with the consummation of the improvements and changes under development at present, the third step is ready to be taken. In this move we will take advantage of the cord construction that has proved its durability and reliability, combine this with a much larger section and a thinner wall and make it possible to ride on low-pressure air for the protection of the car and the greater comfort of the passengers, without any sacrifice in economy.

Someone has facetiously said that Goldberg, the cartoonist, in portraying doughnuts for wheels in his pictures, was the originator of the idea but, while he depicted large-section tires truly enough, the large section is not the whole story necessarily. On the other hand, of his own volition many an automobile owner has allowed his tires to be run under-inflated for his own personal comfort, explaining in a casual way that he did not intend to be shaken to pieces by the air pressures which the tire companies recommended, and that he was willing to sacrifice tire economy if necessary to secure this greater comfort; that is, he wanted to ride on low-pressure air. Also, a few cases are known of 6 or 7-in. thick-walled pneumatic truck-tires and truck rims having been applied to passenger cars and run at low pressure, notably by tire experimenters; this is, presumably, more in the nature of a stunt, since it does not appear that they had any serious thought of pushing the idea for actual commercial application to passenger cars.

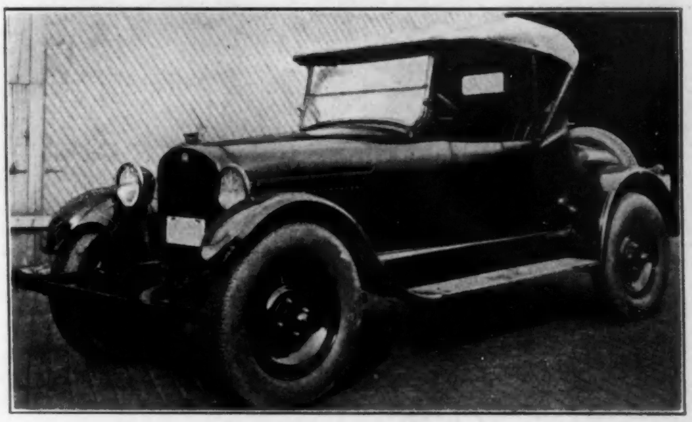

FIG. 1—PASSENGER CAR EQUIPPED WITH FOUR-PLY AIR-CUSHION TIRES

This newest development, the air-cushion tire, is the result of a deliberate attempt to make riding on low-pressure air possible. It is the natural consequence of a strong conviction on my part that there ought to be a way to accomplish it that led the company I represent to take the bold step in going to an extreme and providing carcass flexibility and a section size sufficient to give the tire a larger area of contact with the pavement. Fig. 1 shows my car as it appeared when equipped with the original set of these tires in October, 1922; they were constructed with four plies of cord fabric, molded to $7\frac{1}{4}$-in. section, had a 20-in. wheel diameter and were inflated to a pressure of 18 lb. per sq. in.

FUNDAMENTALS CONSIDERED

The fundamentals of this movement are comparatively simple. If we are to have greater cushioning for comfort and protection against vibrations of the car, the combination of a low air-pressure and a large area of contact must be provided, and by employing such tire constructions that the tire durability will not be impaired. The goal aimed at was to increase the area of contact sufficiently so that air pressures ranging from 20 to 35 lb. per sq. in. could be employed in actual practice.

[1] M.S.A.E.—Manager of the development department, Firestone Tire & Rubber Co., Akron, Ohio.

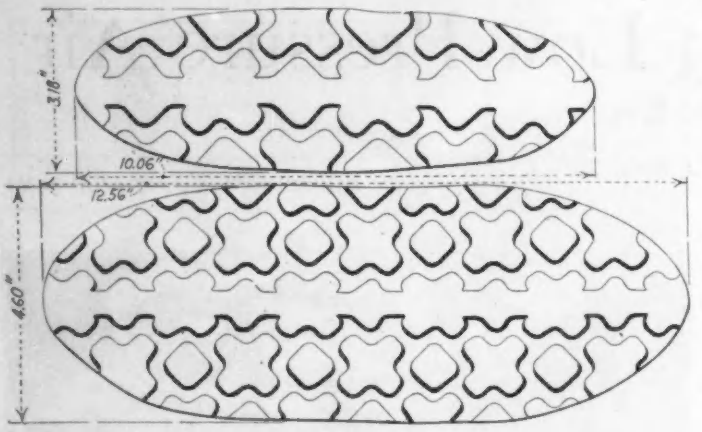

Fig. 2—Comparison of the Tread Imprints of a 7.30 Air-Cushion Tire Having an Inflation-Pressure of 35 Lb. per Sq. In. and a 33 x 5-In. High-Pressure Pneumatic Tire Having an Inflation-Pressure of 65 Lb., Each Tire Having Been Loaded 1700 Lb.

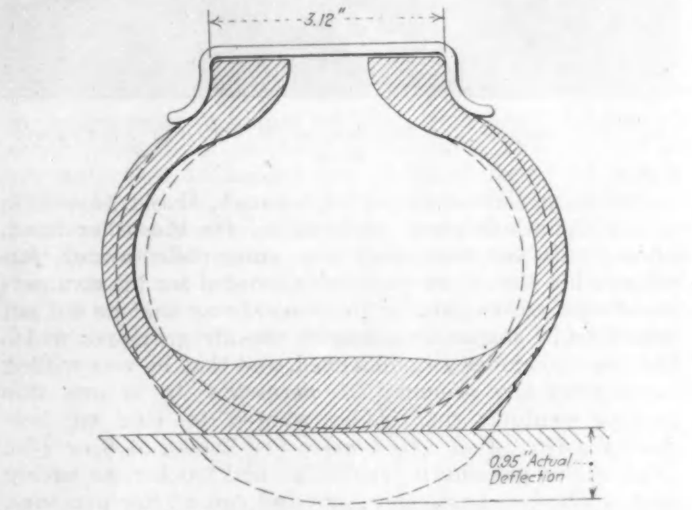

Fig. 3—Vertical Deflection of a 7.30 Air-Cushion Tire when Loaded to 1700 Lb.

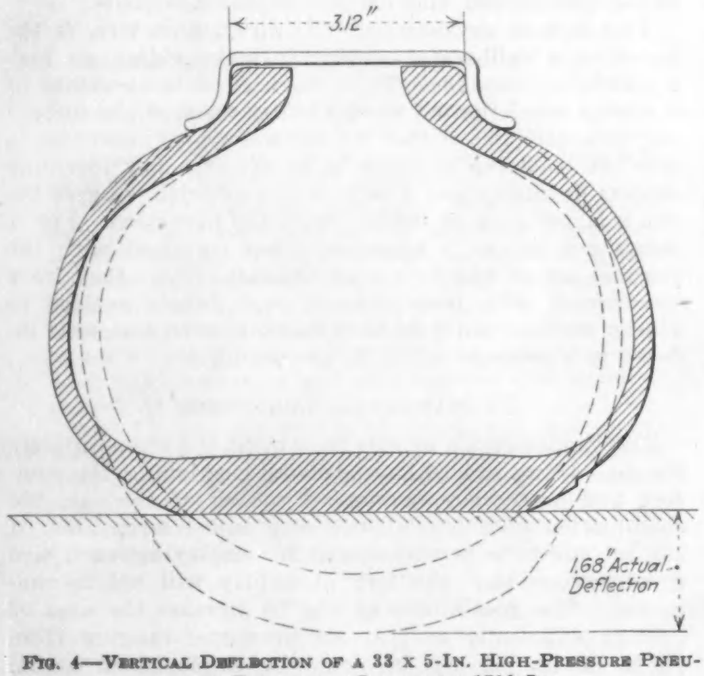

Fig. 4—Vertical Deflection of a 33 x 5-In. High-Pressure Pneumatic Tire when Loaded to 1700 Lb.

In a general way, the contact area of the tread with the road, expressed in square inches, multiplied by the internal air-pressure will give a figure that approximates the load resting on the tire. This is as it should be. It is evident that if a 1000-lb. load is to be imposed on the tire, and due to the limitation in the amount of vertical deflection not more than 20 sq. in. of contact can be obtained, it will require a 50-lb. per sq. in. pressure of air to carry the load. If, however, we can devise some way of increasing the area and still not exceed the proper degree of deflection; for instance, if we can increase the area to 50 sq. in., it will require very much less pressure; in this case a pressure of only 20 lb. per sq. in. is needed to carry the same load. Fig. 2 shows the tread imprint of a 7.30-in. air-cushion tire compared with that of the 33 x 5-in. high-pressure pneumatic-tire, each tire having been loaded to 1700 lb.; but with an air pressure of 35 lb. per sq. in. in the air-cushion tire and 65 lb. per sq. in. in the 33 x 5-in. tire. The vertical deflection of these two tires is shown in Figs. 3 and 4, which are drawn to the same scale to enable one to visualize the cross-sectional difference.

TABLE 1—HIGH-PRESSURE PNEUMATIC CORD-TIRES FOR PASSENGER CARS AND MOTOR TRUCKS

Size, In. Nominal	Size, In. Actual	Number of Plies	Maximum Load, Lb.	Maximum Permissible Deflection, Actual, In.	Maximum Permissible Deflection, Per Cent	Road Contact, Area, Sq. In.	Road Contact, Length, In.
			Passenger-Car Tires				
3½	3.51	4	650	0.68	19.4	10.9	7.20
	3.70		700	0.83	22.4	11.8	7.85
4	4.40	6	1,000	0.81	18.4	17.0	8.90
4½	4.95	6	1,250	0.90	18.1	21.4	9.45
5	5.80	8	1,700	0.95	16.3	26.3	10.00
			Pneumatic Truck-Tires				
6	6.60	8	2,200	0.86	13.0	36.7	9.00
7	7.70	10	3,000	0.92	12.0	45.8	9.60
8	8.80	12	4,000	0.97	11.0	54.4	10.08
9	9.90	14	5,000	0.99	10.0	67.0	11.20
10	11.00	16	6,000	1.10	10.0	79.5	10.35

One of the fundamental conditions of conservative tire use that we recognize is the limitation of the actual vertical deflection of the tire expressed as a percentage relation of the sectional diameter. It has been found that if this percentage of deflection is exceeded, the tires are likely to fail prematurely from two causes: First, tread separation and ply separation are likely to be excessive; second, the flexing localizes half-way up the side-wall and may cause fabric failure on the inside plies. It can be appreciated readily that, in the case of a thick-walled tire, the destructive effect of this flexing will be much more pronounced than in the case of a thin-walled tire. But, if we use low-pressure air, the bursting stresses on the carcass are low enough so that only a few plies are necessary and this, in turn, makes it possible to increase the deflection percentage. Table 1 lists the percentage

TABLE 2—AIR-CUSHION TIRES FOR PASSENGER CARS

Size, In. Nominal	Size, In. Actual	Number of Plies	Maximum Load, Lb.	Maximum Permissible Deflection, Actual, In.	Maximum Permissible Deflection, Per Cent	Road Contact, Area, Sq. In.	Road Contact, Length, In.
4.40	4.40	2 or 4	750	1.01	23	20.2	8.90
5.25	5.25	4	1,000	1.21	23	28.5	9.93
6.20	6.20	4 or 6	1,300	1.42	23	36.7	10.70
7.30	7.30	4 or 6	1,700	1.68	23	48.3	12.50

deflection limitations of high-pressure pneumatics; also, other fundamentals for comparisons to be referred to later.

Our tentative air-cushion-tire schedule offers four section sizes for passenger-car use, each size to be made of no more than six plies, constructed so as to permit their normal use with pressures between 20 and 35 lb. per sq. in. and to be used on rims the width of which is approximately 45 per cent of the tire section. Table 2 shows figures comparative to those of the high-pressure pneumatic-tire.

What Air-Cushion Tires Do For a Car

As to the effect that these tires have on the riding of the car, the first reaction to the occupants is the greater degree of comfort. Road-surface irregularities are toned-

Fig. 5—A 7.30 Air-Cushion Tire with an Inflation-Pressure of 18 Lb. Absorbing the Inequality in the Road Surface Due to Heaved-Up Brick

down and, in most cases, obliterated. Of course, the "ups-and-downs" in the road are still there and the car goes up and down with them, but everything is cushioned so that there are no sharp shocks or jolts; one does not need to watch the road to put his body in tense condition to get over the rough places, nor to be worried about being tossed up from the seat. Furthermore, the driver does not need to pick out all the good places in a rough

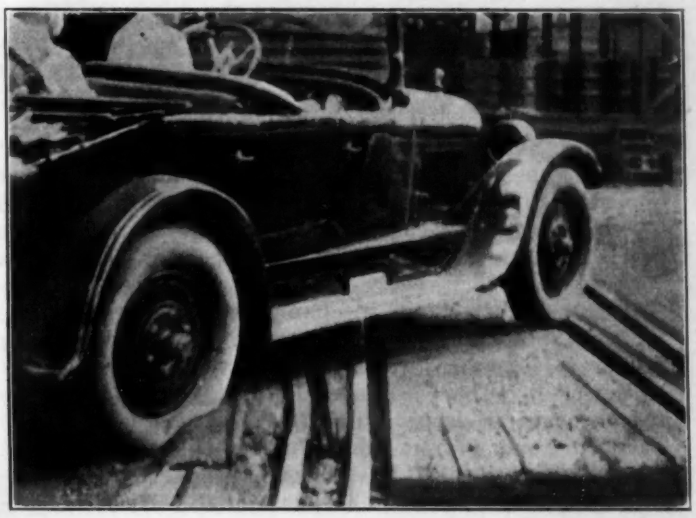

Fig. 6—Car Equipped with Air-Cushion Tires Passing Over a Railroad Crossing

road, because it makes little or no difference whether he takes them in or not.

It is remarkable how a car equipped with 7.30-in. tires will negotiate a frozen road. As an extreme example, I

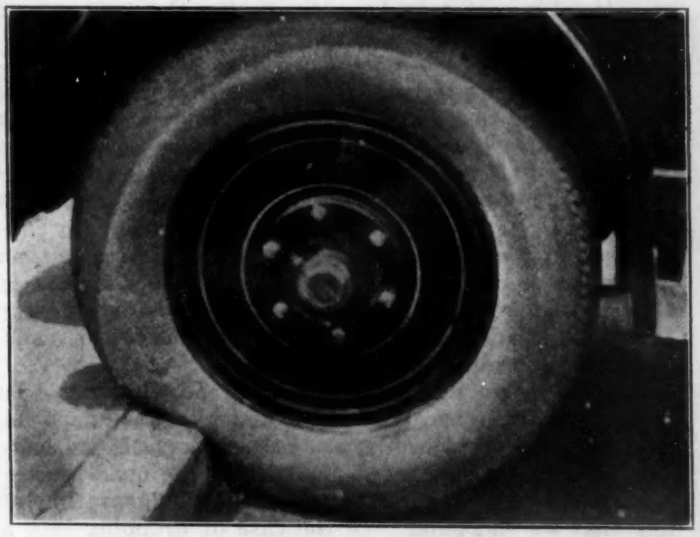

Fig. 7—How Air-Cushion Tires React against the Curb

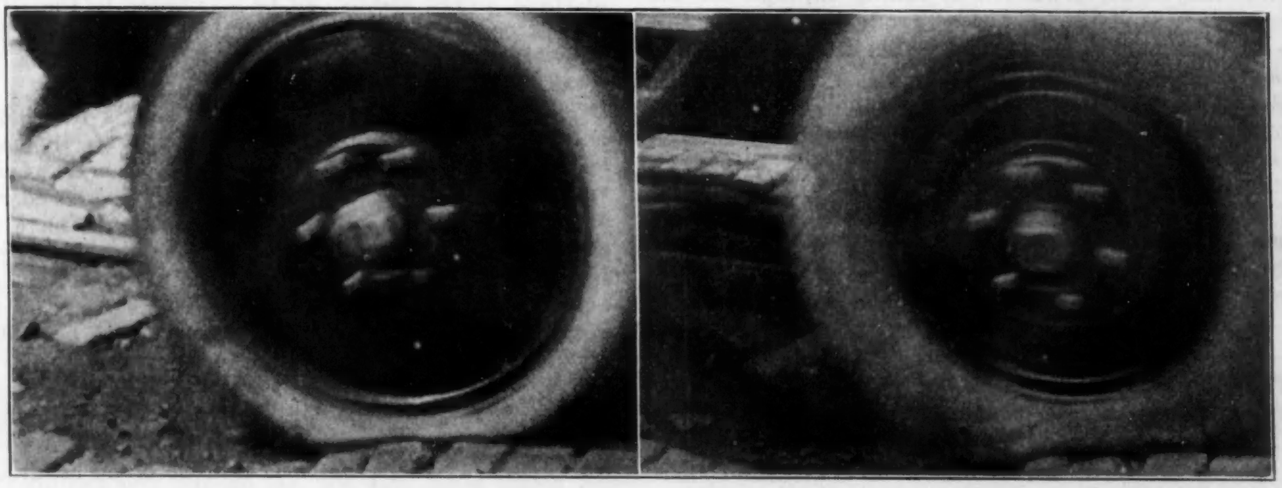

Fig. 8—Comparative Actions of a High-Pressure Pneumatic Tire (at the Left) and an Air-Cushion Tire (at the Right) Rolling Out of the Same Chuck-Hole

have seen a certain car driven over the ties on a railroad track with little discomfort to the occupants. Of extreme convenience is the fact that, in suburban driving where it is necessary to go off the pavement, one does not need to take any special precaution to slacken the speed, because the average rough road usually can be taken at the same speed as that used on the pavement. Another important factor is that, on rough roads, particularly in the country, the air-cushion tires smooth-out the road so that a substantially higher average speed is practicable.

Of equal importance to improving the degree of comfort is the effect on the mechanism and the body of the car itself. So far, no way has presented itself of making deliberate comparisons of the effect of low-pressure air in preserving the car from developing rattles, creaks and mechanical depreciation, but there is no question about its being a tremendous factor; this is due to the fact that everything is cushioned. Compared with high-pressure pneumatics, the sharpness of the shocks is softened very effectively. For example, one of our new test-cars has been running on 6.20-in. air-cushion tires with about 20 to 25 lb. per sq. in. air pressure; for the purpose of comparison, 4-in. regular pneumatic-tires with the proper inflation air-pressure of 50 lb. per sq. in. were substituted. As a result of this, rattles appeared that the test-car driver had never observed before; in fact, with air-cushion equipment, he said there were no rattles, a noticeable contrast when considering the same car on regular high-pressure pneumatics.

Since there are no satisfactory instruments for measuring the cushioning qualities of air-cushion tires, I have resorted to a series of pictures, Figs. 5 to 9, which were taken to make it possible to visualize how the air-cushion tires function. Manifestly, a thin-walled tire having very low air-pressure and large cross-section, with a big area of contact, will roll over and envelop any projections with much less tendency to elevate the axle than will a tire having a thick carcass with half the area of contact and high air-pressure. Figs. 5 to 9 show very vividly to what an extraordinary degree the bricks, rails, and the like are absorbed into the tires.

Regarding ridges and holes in the road which must be negotiated, the tire, the wheel and the axle must be lowered or elevated bodily, as the case may be and, particularly, in the case of a sharp drop as into a chuck-hole. These cases are among the most aggravating of any that we encounter. In the case of dropping into a chuck-hole, the air-cushion tires, having a much greater permissible actual deflection in falling through the distance, are brought to rest more gradually; in fact, they are brought to rest so gradually that the effect is more of a rolling action.

Believing that the use of ultra-rapid motion-picture photography might throw some light on the functioning of air-cushion tires compared with high-pressure pneumatic-tires, we had some motion pictures taken while the cars were operating over a typical road-surface. These pictures show some interesting things; particularly, they enable one to visualize in a strictly comparative way the superior cushioning of the air-cushion tires.

Effects on Car Operation

There seems to be a definite list of questions that arise in the minds of the car designers and the public regarding the application of air-cushion tires and their effects on car operation. Naturally, we have taken all these questions very seriously because it manifestly would be unwise to proceed with any development work on a line of tires that has no prospect of being commercially applicable. I believe we have reasonable answers for all of the practical operating aspects that arise.

Of questions on the various phases of practical car-operation, probably the most frequent is in regard to fuel consumption. In general, the air-cushion tires cause neither more nor less fuel to be consumed than do the high-pressure pneumatics. On actual fuel-consumption, a number of private owners have found that, by keeping account of the fuel used, they noticed a slightly greater mileage per gallon with air-cushion tires. Our most authoritative information, however, is derived from our observations on six taxicabs that ran a total of 20,000 miles during April, 1923, on 7.30-in. air-cushion tires; the fuel consumption averaged 13.5 miles per gal. This compares with a fuel consumption of 12.6 miles per gal. for a larger number of similar cabs that covered many times that amount of mileage on 33 x 4½-in. six-ply tires having an air pressure of 70 lb. per sq. in.

From the viewpoint of fuel economy, so far as tire technique is concerned, it appears that, in the case of the regular pneumatic tires with a smaller tread-contact, it is the internal carcass-friction rather than the tread rolling-resistance that absorbs energy. On the other hand, in the case of the air-cushion tires, the carcass being so thin as to have practically negligible carcass friction, the large area of contact occasions a much greater degree of road friction than in the case of the regular pneumatic tires, and it is probable that these effects would just about balance each other in the two classes of tire. With air-cushion tires, the cars coast just as freely and accelerate practically in the same degree as with high-pressure pneumatic-tires.

Fig. 10 shows the acceleration and coasting observations made on a car equipped alternately with 7.30-in. air-cushion tires having an air pressure of 25 to 28 lb. per sq. in. and with 33 x 4½-in. tires having an air pressure of 50 to 55 lb. per sq. in. The comparative tests were made without disturbing the brakes or bearing adjustments, since the wheel changes were made simply by switching disc wheels that are demountable at the hub.

Effects on Speed and Steering

The question has been raised as to whether, with air-cushion tires, the top speed will be cut down; that is, speeds of 60 m.p.h. and upward. While the evidence is not positive, the indications are that there may be a slight difference. Very likely, any appreciable slackening of these higher speeds can be attributed to the windage resistance of the tire. Unquestionably, tires with such large section covered with non-skid projections would make this a notable factor.

The question next frequently raised is in regard to how the steering is affected. This is perfectly natural, because most drivers have discovered that, when the front tires are soft, there is a slightly increased resistance to steering. From laboratory tests, we have found the area of contact of the air-cushion tires with the road surface to be about twice that of the high-pressure pneumatic tires, and under these conditions one can detect a slight difference in turning the wheel. In ordinary driving this effect is of such minor consequence that it cannot be considered a serious handicap. However, we find that, when the car is in close quarters, such as being parked by a curb, it is more difficult to pull the wheels around when the car has little or no headway.

In some cases the larger tires actually favor the steering. For instance, on streets having trolley-lines,

the front wheels are not deflected at all in making a cross-over from one side of the street to the other, even though the angle at which the car makes the crossing over the rails be the next thing to parallel driving. Another favorable feature is that, when dropping into chuck-holes or off the edge of the pavement, the reaction tending to deflect the car is much less pronounced. In fact, in the latter case, the control is infinitely better in regaining the pavement. It seems to me very probable that as car designers study the problem of fitting air-cushion tires to their different models, changes in steering-gear may be entirely plausible to compensate for any minor effects introduced by the tires.

A reference to the steering-gear brings to mind our

FIG. 9—TWO SIMILAR CARS ON A ROUGH DIRT ROAD SHOWING HOW THE OCCUPANTS OF THE CAR AT THE LEFT, WHICH IS EQUIPPED WITH HIGH-PRESSURE PNEUMATIC TIRES, ARE THROWN UP FROM THEIR SEATS, WHILE THOSE IN THE CAR AT THE RIGHT, WHICH IS EQUIPPED WITH AIR-CUSHION TIRES, RIDE IN COMFORT

unsolved mystery, the front-wheel shimmy. This has been observed and commented upon by certain car engineers in connection with the application of air-cushion tires. Just how far we should go in assigning the cause of this front-wheel shimmy to the application of the large-section low-pressure tires is not clear. I have encountered some cases of front-wheel shimmy on both high-pressure and low-pressure pneumatic tires and, in each case, the trouble has been taken care of by such methods of adjustment and replacing of the parts as the ordinary repair-shop has at its command. However, judging from the prominence that the subject of front-wheel shimmy has been given from a design point of view, it is not unlikely that the low air-pressure may be a factor that will justify the industry in considering it a joint problem for the tire and the car engineers to solve.

TRACTION AND BRAKING CONTROL

The traction and braking control of the car in driving is probably of equal importance with the fuel consumption and the ease of steering. I have not found any way to make comparative measurements of this effect, but can report my own experience which checks with that of every other user of the properly designed air-cushion tires. On wet pavements, with the brakes equalized properly, I have tried every way that I could think of to make my car skid but, so far, the only thing which happens is that the car stops. In the most ticklish traffic

TABLE 3—DISTANCE THE WHEEL DROPS WHEN THE TIRE BECOMES DEFLATED

Air-Cushion Tires		Pneumatic Tires	
Size, In.	Wheel Drop, In.	Size, In.	Wheel Drop, In.
4.40	2⅜	3½ (Clincher)	1⅞
5.25	2 15/16	4	2⅜
6.20	3⅜	4½	2⅞
7.30	4¾	5	3⅞

I have no fear about what I can do in an emergency. The large area of contact, with the greatly increased linear total of non-skid edges that gives a squeegee effect, undoubtedly is the combination that gives such excellent non-skid results.

In contrast to wood block or asphalt are cases of uneven pavement surfaces where the actual area and the button-edge contact is cut down by the road-surface irregularities. In the case of the air-cushion tires, the area is so large and the carcass is so flexible that it folds and rolls over the dips and hollows in the road surface so as to maintain a uniformly large area of contact at all times. This is not true in the case of the high-pressure tires, which are inflated so hard that they lose a great amount of their contact; the result is that the air-cushion tires hold much better on rough pavements. On snow and ice, the control of the car with air-cushion tires is noticeably better than with high-pressure pneumatic tires. This is true particularly in eliminating the tendency to skid sidewise in applying the brakes and rounding corners. In applying the brakes for a quick stop, one has to be very cautious lest the wheels become locked and, should this happen, the result is much the same as with the regular pneumatic tires.

Since front-wheel brakes are being considered so seriously by designers, I think they will do well to investigate thoroughly the capacity of air-cushion tires to control the car. From this point of view, it may be that this new type of tire offers sufficient improvement in braking control to obviate the necessity for front-wheel brakes.

TIRE BLOW-OUTS

The question of danger from a flat tire has come up. If one were driving at 40 to 45 m.p.h. and had a blow-out on the right front tire, what would happen? We are not in a position to make any very positive assertions on this

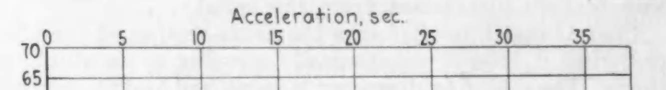

FIG. 10—RESULTS OF ACCELERATION AND COASTING TESTS MADE ON A PASSENGER CAR EQUIPPED ALTERNATELY WITH 34 X 7-IN. (SIZE 7.30) AIR-CUSHION TIRES HAVING INFLATION-PRESSURES OF FROM 25 TO 28 LB. PER SQ. IN. AND 33 X 4½-IN. PNEUMATIC TIRES HAVING AN INFLATION-PRESSURE OF FROM 50 TO 55 LB. PER SQ. IN.

point, as only two blow-outs have occurred in all our testing experience. These occurred on a test car when the car was traveling about 30 m.p.h.; the test-car driver states that it did not in any way cause him to lose control of the car or cause it to display any tendency to become unmanageable. We tried the experiment of producing a flat tire on the right front-wheel of a test car having 7.30-in. air-cushion tires. Starting inflated, but with the inner-tube valve-insides backed-out to deflate the tire rapidly, we ran along at between 35 to 40 m.p.h. for a considerable distance after the tire was entirely deflated. We found it was necessary for the observer to step out on the running-board and actually look at the tire to be sure that it had become fully deflated; the driver found that he could take his hands off of the steering-wheel without producing any tendency to give trouble. This brings up the question of how great the drop is when the tire becomes deflated. Table 3 gives the figures showing the difference between the condition of full inflation and that of a flat tire.

Side-Sway

Some people are apprehensive lest the side-sway be objectionable.. This, in my opinion, is a point of view. I presume that a little more side-sway can be detected and

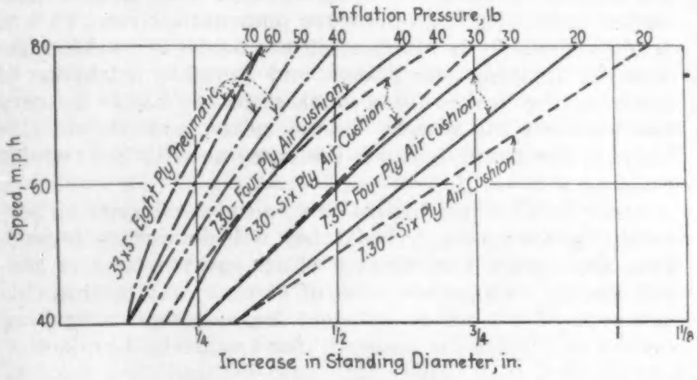

Fig. 11—Curves Showing the Increase in Standing Diameters of Different Tires Due to Centrifugal Force

measured with the air-cushion tires than with the high-pressure pneumatic tires; but it is my observation that, after becoming accustomed to the car, all thought about this feature disappears from the mind.

Centrifugal force deforms the cross-section of the tire, changing it from a substantially circular to an elliptical shape. The standing diameter is increased and the section diameter is diminished. The figures given in Fig. 11 were obtained simply by revolving the tire on a shaft and measuring with an indicator that was arranged to roll against the tread.

Another feature of control in driving is the new attitude on the part of the driver toward the roadway ahead of him, particularly if he does much driving after dark. He soon finds that whereas formerly he slowed-down or steered for the smoothest places in the street as a matter of course, this is not necessary with air-cushion tires. Of course, the very worst chuck-holes might be avoided, but the driver soon learns that he need not slow-up for rough spots, as he can take them without slackening speed.

While it is apparent that the car can be driven much faster over the average highways as we find them with almost complete elimination of vibration, I am wondering whether this higher average speed may not lead to more or less serious consequences from another source. Will the powerplant and the transmission system withstand this higher average speed without suffering damage? Naturally, the conclusions on this point will need to be drawn by those skilled in observing such things and particularly by making direct comparisons with tires on the old equipment. It is my opinion that the increased speed will amount to somewhere between 10 and 30 per cent.

Galloping and Front-Wheel Toe-In

For some reason that is not very clear to me, cars equipped with air-cushion tires develop a violent galloping when they are not equipped with shock-absorbers. This is so noticeable that I can predict disappointment to any one equipping a car without the use of shock-absorbers. Possibly spring designers can furnish some explanation for this situation.

At present, it appears that the amount of gather or toe-in on the front wheels will have to be adjusted very delicately to prevent the excessive wear that appears with improper alignment. Our observations point clearly to the fact that air-cushion tires are more sensitive to improper alignment than are the high-pressure pneumatic tires.

Two features of car operation that register against air-cushion tires are their mud-splashing and dust-raising propensities. The larger-section tires with the greater area of contact spatter mud much more than any other tires heretofore brought out and, as for dust-raising on country roads, it is terrible. I believe that a motor-truck convoy could not raise more dust in traveling along a dry country road in summer than my own car raises. While this may be a minor point, it may develop into an objection.

Durability and Tire Cost

All our development work on air-cushion tires has been carried out under actual road-test conditions. To date, we have run a total of 850,000 tire-miles under test observations, and evidence points to average mileages at least as high as those enjoyed with regular pneumatic tires. The character of the failures unquestionably will be somewhat different. For instance, ply separation and tread separation will be minimized in air-cushion tires and, with these eliminated, the most prominent troubles will be fabric breaks in the carcass; also, punctures and rapid tread-wear on the front wheels when they are not aligned properly. Many people have questioned whether, with such a thin tire, punctures will not be sufficiently numerous to be of considerable annoyance. There are no grounds for concern on this score. In 50,000 car-miles of operation of our test fleet there were seven punctures, and in 100,000 miles of operation in taxicab service there was an average of one puncture for each 3700 taxicab-miles. The explanation is found in the fact that the tire, being not so taut and hard and drum-like, yields rather than becomes pierced by the puncturing object.

The light carcass-structure necessary in these tires also raises the question as to whether they have the stamina to withstand the rough usage to which the heavier cars are often put. A large measure of our road-testing development was on tires of the four-ply construction. Their performance under test conditions is repeatedly showing great ruggedness. One of these four-ply 7.30-in. test-tires gave out after having worn through the breaker and three of the four plies, as shown in Fig. 12. The interesting point is that it continued to run on this single ply for a considerable distance before finally blowing-out by bursting open at this point, as can be seen clearly in Fig. 12. When one considers that this was on the front wheel of one of our heaviest cars, which was touring in

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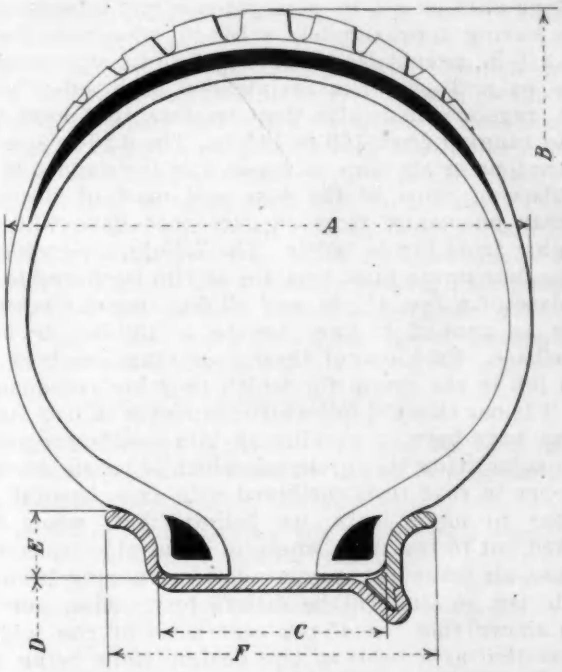
the South, it emphasizes the part that low inflation-pressure plays in making the casing so soft and yielding that the destructive reaction of ordinary driving largely is eliminated. In other words, no part of the tire is subject to high intensity of stress at any one point, which is contrary to the condition that applies to the high-pressure pneumatic tires. There is no doubt that this lessened intensity of pressure is responsible for the almost complete absence of tread and ply separation. By dwelling on Figs. 5 to 9, showing the tires rolling over obstructions in the road, one can more or less sense that the tire, instead of resisting the blow that the road gives, yields with no destructive effect. For instance, one interesting point is the fact that air-cushion tires run their life with no tread-cuts whatever. I have seen many tires that have covered more than 7500 miles which were so free from tread-cuts that, had they been washed-up, they could be taken for new. The same thing applies to the side-wall of the tire; that is, in running in ruts or against curbs or loose rocks in the road, an ordinary pneumatic tire is apt to have the side-wall scraped or abraded. With air-cushion tires, however, the tire yields to the blow, thereby protecting itself and escaping injury.

Misalignment of the front wheels manifests itself very quickly by rapid tread-wear. In the few cases that we have observed, however, we have had no trouble in eliminating this by prompt attention to the realignment.

With long tire life, protection of the car against destructive vibration effects and favorable fuel-consumption, I believe the cost of car operation will be lower.

Fig. 12—One of the Four-Ply 7.30 Test-Tires That Failed after Having Worn through the Breaker and Three of the Plies

At present, it is not possible to give any comparative tire costs because we have not had an opportunity to get volume production figures. The manufacturing details will



	Principal Dimensions							
Nominal Size	Actual-Tire Section A	Overall Diameter B	Rim Width C	Rim Diameter D	Flange Height E	Overall Width of Rim F	Ratio of C/A, per cent	Rim-Size Old Design
4.40	4.40	29½	2.00	20	0.59	3.06	45+	26x3
5.25	5.25	31¼	2.31	20	0.69	3.43	44+	27x3½
6.20	6.20	33¼	2.68	20	0.78	3.89	43+	28x4
7.30	7.30	35¼	3.12	20	0.87	4.38	43-	29x4½

Fig. 13—Tentative Proposal of Air-Cushion Tire and Rim Sizes for Passenger Cars

be sufficiently different from those of regular pneumatic tires to have a slight influence tending to increase the tire cost.

Other factors that have a larger influence on the cost element than the manufacturing processes are the section size of the tire and the number of plies to be used. Comments are made and comparisons are drawn on section measurements and the number of plies, later in the paper. In a general way, as a result of our development work, I have concluded that the amount of cotton and rubber used in air-cushion tires need not be much greater, if any, than that in the tires which they replace. Therefore, if we increase the section, we can make a corresponding decrease in the thickness of the walls of the tire. However, until the actual sectional sizes to be put on the market are decided upon, it is not expedient to attempt to forecast precise cost figures.

Low-Pressure Tires Applied to Automobiles

The foregoing covers our research development-work on the fundamental air-cushion idea. The result of all these activities since early in the fall of 1922 has been to confirm our judgment that we are working on a sound basis. The next logical move is to translate the low-pressure principles into practical application to motor cars, with the aid of the motor-car engineers.

To provoke discussion and drawn forth constructive criticism, I know of no better way than to propose what appears to me to be an ideal line-up of tires and rims. This was suggested earlier in the paper and is now presented more in detail in Fig. 13, which shows an outline drawing of a tire and a rim and gives the principal dimensions. The 4.40-in. air cushion tires of either two

or four plies on a 3-in. straight-side rim is proposed for cars having approximately a 100-in. wheelbase that now use 3½-in. pneumatic tires. The 5.25-in. size using four plies on a 3½-in. rim is intended as a substitute for 4-in. regular pneumatic tires on cars that have wheelbases ranging from 109 to 115 in. The 6.20-in size using either four or six plies on a 4-in. rim is designed to serve in place of some of the 4-in. and most of the 4½-in. regular pneumatic tires on cars that have wheelbases ranging from 118 to 126 in. The 7.30-in. air-cushion tire using four or six plies on a 4½-in rim is offered to serve in place of a few 4½-in. and all 5-in. regular pneumatic tires as applied to cars having a 130-in., or longer, wheelbase. Each one of these four sizes has been fitted to a job in the group for which they are recommended, and it is our thought to receive comments on how successful we have been in working up this specific proposal.

In submitting this proposal, which is based on our experience in road tests combined with experimental applications to motor cars, we believe that, when finally worked out to the state where it is suitable for commercial use, air-pressure recommendations ranging from 20 to 35 lb. per sq. in. will be satisfactory. Also, our tests have shown that the 45-per cent ratio of rim width to tire section as a basis of tire design, while being somewhat of a radical departure from the 10 to 12-year-old criterion of 66 per cent, is practicable so far as tire performance is concerned, has the exceptionally meritorious advantage of making a substantial reduction in the unsprung weight and, finally, is the most efficient combination of the number of plies and tire section to result in tire costs that will not be burdensome to the industry.

It seems to me that the car designers must view this problem from two aspects: first, whether there is anything inherent in the application of such tires to the car that makes them undesirable; second, the specific changes in the body, the axles, the fenders and the other features of car design that the designer would need to undertake to accommodate some changes in physical measurements.

Dwelling for the moment on the fundamentals underlying this movement, I ask: Does the motor-car industry wish to go as far as this proposal? Does the industry wish to have narrower rims and a light carcass-structure in the tire, or would it rather go to some half-way point? For instance, whereas I propose a 7.30-in. four or six-ply tire on a 4½-in. rim for cars having a 130-in. wheelbase, would it be along a line of less resistance and more appeal to the car builders to use a smaller section, say a 6-in. six-ply tire on a 5-in. rim, or would the 7.30-in. section tire be suitable if it were on a wider rim; and so on down the list of sizes? Bearing in mind always that this ideal line-up employs the rim of lightest weight, the lowest air-pressure and the least costly tire construction, how should we modify the proposal?

To take advantage of low-pressure air, a large area of contact is necessary and a large area of contact cannot be had without a high percentage of deflection; this in turn, calls for a thin carcass and a large section. What are the problems of practical application that the car

TABLE 4—WEIGHTS AND STANDING DIAMETERS OF TIRES

Air-Cushion Tires							Pneumatic Tires					
		Weights, Lb.						Weights, Lb.				
Size, In.	Number of Plies	Tire	Tube	Demountable Rim	Total	Standing Diameter, In.	Size, In.	Tire	Tube	Demountable Rim	Total	Standing Diameter, In. High and Low Values of Tires on the Market
4.40	2	13.3	2.7	11.4	27.4	29½	30x3½(a)	11.9	1.8	12.0(b)	25.7	30⅝ to 31⅝
4.40	4	14.5	2.7	11.4	28.6		Oversize Clincher Cord	14.0	2.1	12.0(b)	28.1	
							Straight-Sided Cord	14.1	2.1	15.5	31.7	
							31x4	21.3	2.7	16.8	40.8	32⅛ to 33
5.25	4	21.1	4.0	12.8	37.9	31¼	32x4	21.7	2.8	17.4	41.9	32½ to 34
							33x4	22.7	2.9	18.0	43.7	34⅝(c)
6.20	4	27.2	4.8	14.8	46.8		29x4½	22.8	3.1	18.8	44.7	30½(c)
						33¼	32x4½	25.6	3.4	21.6	50.6	33⅛ to 34⅛
6.20	6	31.7	4.8	14.8	51.3		33x4½	25.9	3.5	22.5	46.8	34¼ to 35
							34x4½	27.4	3.6	23.5	54.5	35⅛ to 36⅛
							30x5	29.3	4.0	18.8	52.1	32(c)
7.30	4	34.3	5.2	18.8	58.3	35¼	33x5	37.2	4.6	21.6	63.4	34⅝ to 36
7.30	6	38.8	5.2	18.8	62.8		35x5	39.4	4.9	23.5	67.8	36½ to 37½

(a) Regular clincher cord
(b) Clincher rim
(c) Firestone

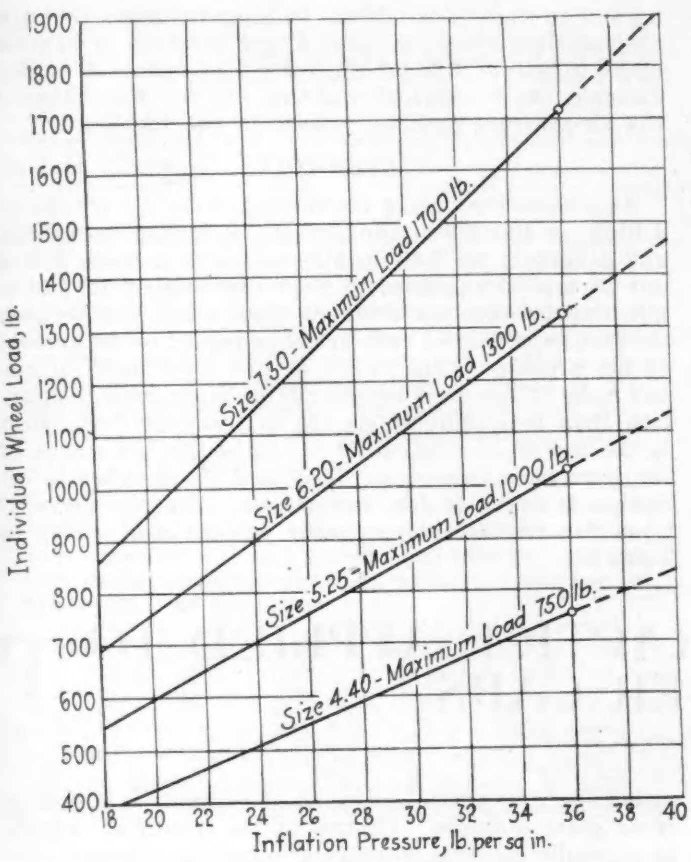


FIG. 14—CURVES SHOWING THE INFLATION-PRESSURE REQUIRED TO SUPPORT A GIVEN WHEEL-LOAD

designer must recognize and master? Are they fundamental and far-reaching, or are they merely clearance and gear-ratio alterations?

Changes in fender, body and brake-drum clearances and also changes in the width of tread of the car, in fitting air-cushion tires, bring up a very complex situation. But it must be accepted as a foregone conclusion that any change in tire equipment that results in the use of larger sections and smaller rim-diameters is very likely to bring about interferences and changed relations of the parts, which must be provided for. It is hoped that the automobile industry will not requisition more than one standing diameter for each section. The tire manufacturers have always been dreaming of the time when they would not need to make a series of standing diameters for each section and, whatever the final disposition of this matter may be, I bespeak for the tire industry a serious attempt to carry out some such program.

Table 4 gives weights of tires, tubes and two-piece rims such as are used for disc or wire wheels, and with the standing diameters of the tires to furnish a direct comparison of the air-cushion with the pneumatic tires.

TIRE-SIZE NOMENCLATURE

Reverting to the schedule as proposed, it will be noted that a new size-nomenclature is included. It has always seemed to me that the sizes of the tires are so far-fetched that I could not resist the temptation to propose a new disposition of this matter. I think everybody is aware that a 34 x 7-in. tire, for instance, has no part of the tire that measures 34 in. and, likewise, no part of the tire that measures 7 in. I propose that, when we finally work into air-cushion tires, the true section-size be used as the name size. It does not strike me as necessary to give a standing diameter, since there will be only one standing diameter for each section.

It is my belief that, in introducing the air-cushion tire, the industry should start with the firm determination to make oversizing unnecessary and even that it should not provide for it. Years ago, two factors made oversizing a very desirable thing. I refer to our positive lack of knowledge of how to make good tires in the early days, and to the fact that car builders did not appreciate the desirability of ample sections. That day has long since passed and, at present, the instances in which the owner needs to put on an oversize tire are extremely rare. I wish we might say the same thing about pneumatic equipment for motor trucks!

LIMITATION OF TIRE DEFLECTION

Earlier in the paper, I pointed out that the limitation of the load and inflation combination of any pneumatic

TABLE 5—RECOMMENDATIONS FOR AIR-CUSHION TIRE-EQUIPMENT AND AIR PRESSURES

Data obtained from the Tire & Rim Association, May, 1923						Recommendations for Ford Car		
				Weight Ready for Road with Full Passenger Load, Lb.		Air-Cushion-Tire Recommendations		
							Air Pressure, Lb. per Sq. In.	
Model No.	Wheel Base, In.	Number of Passengers	Type of Body	Front	Rear	Size, In.	Front	Rear
....	....	....	Touring	1,000	1,500	4.40	23	35
....	....	....	Roadster	975	925	4.40	23	23
....	....	....	Sedan	1,040	1,675	4.40	24	38
....	....	....	Coupe	1,085	1,200	4.40	24	28
Data obtained from the Buick Motor Car Co., May, 1923						Recommendations for Buick-Four Car		
23-34	....	2	Roadster	1,395	1,390	5.25	24	18
23-35	....	5	Touring	1,375	1,950	5.25	24	34
23-36	....	3	Coupe	1,500	1,550	5.25	26	26
23-37	....	5	Sedan	1,500	2,200	5.25	26	38
23-38	....	5	Touring	1,500	2,100	5.25	26	37
Data obtained from a questionnaire filled out by the Jordan Motor Car Co., Inc., May, 1923						Recommendations for Jordan Car		
M X	120	5	Touring	1,630	2,335	6.20	21	32
M X	120	5	Brougham, Four-Door	1,700	2,560	6.20	23	35
M X	120	2	Road	1,600	1,760	6.20	21	24
H	124½	4	Sport	1,700	2,275	6.20	23	31
H	124½	5	Sedan	1,860	2,645	6.20	25	35
Data obtained from the Lincoln Motor Co., May, 1923						Recommendations for Lincoln Car		
117	136	7	Sedan	2,360	3,610	7.30	25	38
118	136	7	Limousine	2,340	3,610	7.30	25	38
120	136	7	Town Car, Open Drive Limousine	2,260	3,470	7.30	23	36
123	136	4	Phaeton	2,170	2,930	7.30	22	32
124	136	7	Touring	2,340	3,250	7.30	25	34
125	136	4	Sedan	2,250	3,130	7.30	23	33
126	136	4	Coupe	2,600	2,940	7.30	27	31
129	136	5	Sedan	2,270	3,210	7.30	24	34
130	136	2	Roadster	2,120	2,275	7.30	23	24

tire is the percentage of deflection, and I gave a schedule of the figures conventionally in use today. I propose that the deflection of the air-cushion tires be limited to approximately 23 per cent of their section diameter. Having decided on this, it is a very simple matter to decide on the load and the inflation-pressure schedule by weighing the loads that the 23-per cent deflection will carry per each pound of inflation. This is set forth in graphic form in Fig. 14; I propose this as a load and inflation-pressure schedule. In applying it in practice, I believe it unwise only to publish the graph along with the price-lists and try to translate it into a table of load and inflation pressures as has been done in the past. It seems to me that the only logical thing to do is for each car builder to weigh the front and the rear of each of his models with full-passenger load. With the tire equipment decided, check off the proper inflation for each end of the car, stamp it on a small plate and attach it to the car in some conspicuous place so that the car-owner can feel that this subject has been given consideration by the car builder and that he has the builder's best judgment as a guide to what he should do. It is my judgment that air-cushion tires should be inflated very carefully and should check to within 1 lb. of the correct pressure. A typical example, one for each size of tire, and the disposition of the air-pressure problem, appear in the Appendix.

APPENDIX

As a basis for stating recommendations, a Ford car on 4.40-in., a Buick-Four on 5.25-in., a Jordan on 6.20-in. and a Lincoln on 7.30-in. air-cushion tires were picked out as typical examples to show our method of distinguishing between the different models and also between the front and rear of each model in regard to the amount of air pressure. The range of pressures used on any one make of car must necessarily be given greater attention than heretofore if we are to enjoy the best effect in the use of air-cushion tires. Of course, all makes of car have been treated similarly and the detailed information is available for each maker. The recommendations for the foregoing makes of car are stated in Table 5.

AIRCRAFT-ENGINE PRACTICE APPLIED TO PASSENGER CARS

(*Concluded from p.* 22)

dirt on the cylinder walls and the fins may not have much effect on the cooling of a small low-duty lighting-engine, this is no proof that it is not desirable to design so that dirt deposition will be a minimum and that any such accumulation shall be readily apparent, accessible and easily removed. One highly successful manufacturer of air-cooled aircraft-engines recommends that the dirt accumulation on the cylinders should be removed after every flight; but, while such precautions are entirely unnecessary on a car engine, the effect of scale deposits in water-cooled engines should be sufficient to show that heat-insulating deposits are undesirable on the surfaces to be cooled. I think that Mr. Dicksee is on rather unsafe ground when he attempts to draw so many conclusions on air-cooled engines generally from experience obtained with a small low-duty engine.

The characteristics of the air flow in the cells of the axial and circumferential-fin types are of radically different orders. In the axial-fin type the slowly moving air is accelerated suddenly on entering the cell and, in addition, has added entry losses due to the square edges usually found on the fins in this type. In the circumferential-fin type, the air enters the cell at a low velocity over rounded fin ends and is accelerated gradually toward the throat, the plan shape of the throat somewhat resembling a venturi, as shown in Fig. 15 of the paper. This condition will exist in either a multi-cylinder engine or a cowled single-cylinder engine.

Cylinder-barrel temperatures do not in general exceed 350 deg. fahr. in aircraft engines, but it would be rather daring to suggest that this is the maximum allowable. I have seen a 4-in.-bore aircraft-engine cylinder run wide-open for many hours with all the fins removed from the barrel, without any trouble occurring. After this test the piston skirt was almost completely covered with black tarry oil, but was otherwise in sound condition. The above test was, of course, with a loose-fitting aluminum aircraft-type piston and ample lubrication; with car-engine conditions, the result might by very different.

The problem of cylinder-temperature control in air-cooled engines mentioned by Dr. Dickinson is a matter of no great difficulty. Control of the cooling-air supply by manually operated shutters or otherwise thermostatically controlled by the cylinder-head temperature or by the temperature of the cooling-air after it has passed over the engine, provide a ready means of control of the engine temperature. In any case, the air-cooled engine has a considerable advantage over the water-cooled type, owing to the much smaller heat-content of the engine at its normal working temperature; thus, the air-cooled type will reach its working temperature in a much shorter period. One builder of air-cooled cars has found that the rapid warming-up materially reduces the carbon deposit.

The effect of the cylinder-wall temperature upon the fuel economy is not thoroughly known, and some recent work by the Engineering Division is of interest in this connection, although conducted with wide-open throttle and aircraft fuel. Since the publication of the paper, further work has been done on the cast-iron Type-K cylinder. All the cooling fins were removed and a steel water-jacket welded on. In this form, no increase of output was obtained; the fuel consumption with which the maximum load could be held was reduced by about 4 per cent, although the minimum fuel-consumption obtainable was no lower than with the air-cooled cylinder. In spite of the fact that in the water-cooled cylinder the wall temperature at T_1, as shown in Fig. 1 of the paper, was only about 185 deg. fahr., the tendency to detonation was reduced but slightly. This is remarkable when it is considered that the air-cooled cylinder developed a temperature of more than 700 deg. fahr. at T_1 under similar conditions.

The foregoing results tend to confirm Mr. Grimes' observations regarding cylinder temperature and fuel economy, but it may be well to state that, in general, high wall-temperatures in air-cooled cylinders result in an excessive fuel-consumption at full throttle; so much so that, in fact, such engines, and the Renault and early R.A.E. designs come in this class, are more suitably described as fuel-cooled than air-cooled.

Vol. XIII July, 1923 No. 1

Science and Engineering

By J. H. Hunt[1] Indiana Section Paper

Defining science as "the search for and the classification of the knowledge of natural phenomena," and giving a definition of engineering as being "the application of the materials and the forces of nature to the use of mankind," the author discourses at some length in comparing the conditions under which a scientist works with those that affect the work of the engineer. Time limitations for completed work, and the relations of theory and practice are accorded somewhat similar treatment.

Several examples are given showing how the engineer and the scientist have vied with each other in making progress, and predictions are made that other new materials will be discovered and that the scientist will communicate the scientific method of working to the engineer of the future.

The relations between science and engineering involves such important problems affecting the future of the engineer, that it is really very presumptuous for one who knows only a little about engineering, and really nothing about science, to attempt to discuss them. However, some points can be made in the hope that better qualified persons will take up the subject.

We hear much about "pure science" as being something very distinct from, and possibly elevated above, commercial affairs. If there is such a thing as "pure" science, it is science pursued for its own sake, without regard to the value or the cost of the information obtained. The attitude of the pure scientist is explained, in a way, by a story told of a certain meeting of a mathematical society. A very learned specialist in a very little known form of mathematics read a paper covering the results of several years' work and concluded with the pious hope that his work was so intricate, and so far removed from the ordinary types of mathematical knowledge, that there was no danger that this new found knowledge could be polluted by being used by anyone but a mathematician. The discussion was opened by a physicist who stated that he had been looking for a mathematical tool capable of solving a problem that had baffled him for 2 years, and the mathematician had just supplied him with this tool. I have no doubt that, sooner or later, if it has not happened already, some inventor or some engineer will use this same principle in some device in the practical affairs of mankind.

Illustrative of this same viewpoint, a story is told of Joseph Henry, who was one of the fathers of American investigation in physical phenomena. Following the work of Faraday, he studied the behavior and the laws of the electromagnet, and published a theory explaining how electromagnets might be designed. It is said that he was highly indignant at a friend who suggested that Henry had really invented the telegraph, and that he should have patented it, instead of leaving it to Morse. While the story may not be true, the fact that it has been repeated for years illustrates the point of view of the scientist of that time, and for much of the time from Henry's day until the present. Fortunately for the progress of mankind, there are few scientists today who prefer to work on problems having no prospect of application to human affairs. The time between a discovery and its practical application grows shorter with every decade.

To simplify our discussion, we will define science as "the search for and the classification of the knowledge of natural phenomena," and engineering as "the application of the materials and the forces of nature to the use of mankind." These definitions are not so good as some others, but will be sufficient for our immediate purpose. A comparison of the conditions under which a scientist works with the conditions affecting the work of the engineer will explain many of the relations between their work.

Scientific Working Conditions

When we visit the laboratories of the scientists, whether in the university, a Government department or a commercial-research organization, the first thing that impresses us is the extent to which the scientist works as an individual. He not only plans his work, but sets up his own apparatus. Frequently, he designs the auxiliary equipment and is very likely to make a considerable portion of it with his own hands. This statement is more nearly true of the university worker than of the laboratory man in a large industry, but it is true to a much larger extent for the latter than for the engineer. Not only is the work done on an individualistic basis, but the reports are made on the same basis. The scientist is very careful to give credit to predecessors and colleagues, and expects to and does receive personal credit for his own contribution. This results in his coming into competition to a certain degree with the workers in his specialty over the whole world. This tends not only to give him a greater respect for himself and his work but also to make him very careful in his claims for his work, for he knows that it will be subjected to a careful analysis by men every bit as good as he is, with the possibility that much better minds will review it, locate any possible fault and overthrow any unfounded claim.

The important thing to the scientist is accuracy. Cost, in time or money, enters in no way into his calculations, provided he can obtain the necessary minimum of money for the needed equipment. Since no commercial value is placed on the result, he does not need to concern himself about the ratio between the cost and the value of the product. This attitude is of course perfectly justified, since no one can place a value on a new scientific fact. It is only a little over 90 years since Faraday demonstrated the laws of electromagnetic induction. Without a knowledge of these, practically all of our electrical applications in the arts today would be out of the question. It is said that at the end of his very simple, original demonstration, a lady in the audience asked "Of what use are these new phenomena?" and that Faraday answered, "Of what use is a new-born child?" The question and the answer typify clearly the usual attitude of the public and of the scientist.

The scientist not only publishes the results of his work as an individual, but he is under considerable pressure

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to do so. It is a vital part of his creed to give the results of his work to other scientists as soon as possible. He not only feels it a duty to publish early, but also it is very much to his advantage to do so because, in the scientific world, a man is rated largely on the basis of the work in which he succeeds in anticipating all others. If his work is supported by public or semi-public funds, as is the case at a university or in the Government departments, it is very much to the advantage of the institution to have him publish and so establish before the world in general that good work is being carried on in the institution with which he is connected. Obviously, when a scientist is employed by a commercial organization, prompt publication is not always possible. There is, as a result of this condition, a disposition on the part of scientists to avoid commercial work in spite of the great opportunities, unless the salary is considerably higher than in the university field.

As a result of the lack of pressure for immediate results and because of the necessity of giving credit to all predecessors, the scientist gives considerable time to a preliminary study of his problem and to reading all of the publications touching on it. Ordinarily, he will not repeat the work of another investigator unless the results of the first man are a point of controversy, or unless new methods have been developed giving promise of a greater degree of accuracy than has been obtained previously. Because of the desire for great accuracy and the wish to carry through a piece of work that will give positive results, scientists as a group are likely to pick out points for attack that give a promise of leading directly to results and, as a result of the work being so largely a matter of individual choice, many gaps are likely to be left in a given field of science. It sometimes seems to an onlooker that too much attention is given to definite detail, and not enough to correlation.

Engineering Working Conditions

The conditions surrounding the work of the engineer are well known, but I will refer briefly to the more significant points to emphasize the differences from the situation of the scientist. First, in a manufacturing organization at least, the engineer works as a part of this organization. If he is to be successful, he uses this organization in every way possible. He never does anything in the way of preparation himself that can be taken care of satisfactorily otherwise. In most organizations, he will get along better if he permits other groups to contribute everything that they will do without pressure. If he doubts some of the results, it often will be a good policy to check-up outside of regular hours and without comment. During the engineer's earlier years in his profession, he will not be likely to receive very much personal credit inside his organization and none outside of it. As he progresses, he may get into a situation where he gets more than his share of credit for the engineering accomplishments of his organization. During this period, however, he is likely to get into a position where his work does not receive the open criticism of men of equal standing as does the scientist, as the results of his work are affected greatly by the manufacturing ability of his organization. Many a piece of mediocre engineering has been saved by a good manufacturing and service organization, and some excellent engineering has been ruined by a manufacturing division that cannot see its way to new methods, or by a lack of proper education of the people who have to service this product. A good engineer will of course take full account of these possibilities in advance, but this does not insure that his work will be judged by other engineers of equal ability until his firm is definitely committed to a product that may lead to bankruptcy.

As a general proposition the engineer cannot publish very much about his work when it is new. His intended publications are likely to be subjected to censorship from such widely diverse viewpoints as those of the patent and the sales departments of his company. When these two groups are through, there is usually not enough left of his proposed paper to justify publication anywhere. Many have doubtless noticed that, in many lines in the pre-war days, the foreign technical press seemed to be more worthwhile reading than the American in the same line. While Europe was often in advance of us, the difference on the average was not so great as the technical magazine would often indicate. The foreign engineer was in a position to give his results to the world sooner than the American, for two general reasons. The first of these is the result of the difference in the patent laws. In America, it is often years after the patent application is filed before it is definitely settled whether there was an invention, and who made this invention. It is hardly necessary to remind automobile men of the Selden patent. Until such questions are finally settled, anything that any engineer says about the subject is liable to be used or misused in a patent controversy. Foreign patents, as a general proposition, go to the party first applying rather than to one who claims to be the inventor, and action is usually more prompt than in the United States. As a result, the patent situation clears up much earlier. Relatively more business is done by small companies in Europe than in America, these companies calling in outside consultants for all except routine engineering work. These gentlemen frequently have contracts giving them certain rights in the results of their work. The papers they publish become high-class advertising, not only of the particular result but of the engineer's ability to accomplish these results. The technical press naturally benefits.

The engineer must above all things count costs, not only the cost of producing the final result but also the cost of obtaining the data that will enable this product to be designed. If he fails in either, he will cause his company great difficulty. Some years ago the following advertisement appeared in an electrical magazine: "Wanted—An engineer to design a line of small direct-current motors, no experimenter need apply." This particular company would never get a satisfactory engineer on that basis, but it is pretty safe to say that it was in the pain of parting with an engineer who had failed to estimate correctly the cost of his development work. The engineer must have a pretty definite idea as to the value of a piece of information he expects to get by experimentation; otherwise, he can easily spend more than it is worth in trying to get it. Because of a frequent failure to analyze properly, he often fails to have much of a picture as to what it is likely to cost to get the information, and this is one of the lines in which the engineer needs to improve his work.

Time Factors

The engineer is always working against a due date. Sometimes it is a bogey he sets in his own mind and sometimes it is set by the management, but always there is a possibility that some competitor will reach the result he has in mind first. He is, therefore, under a great temptation to start work before he has studied the problem properly. Usually he does not give enough attention to what has gone before, and this attitude is

unfortunately partially justified by the fact that so many engineering data that have been published are almost worthless except to the man who obtained them, because the conditions surrounding the work were not set out in sufficient detail and it is not safe to make very many deductions. Also, most successful engineering is done along lines where others have made only partial success or even failures. This fact, however, does not justify the complete rejection of all that can be learned of a predecessor's work, and engineers frequently are guilty of just this fault.

The engineer is under more pressure than the scientist to cover rather completely the field of his own work. Too much is dependent upon his making sure that some unforeseen and, apparently, small factor will not interfere with the success of his apparatus. Since it is humanly impossible to predict all of the details that may arise, the engineer is compelled to make more or less blind thrusts in various directions to determine what may possibly happen. An automobile engineer calls these thrusts road tests, and they take the form of sending a completed assembly of more or less completely tried details to the Pacific coast or to Florida and back, depending upon the inclination of the engineer. Sometimes he learns something he could not have learned in the laboratory or by a dynamometer test, but more usually every point he thinks has been settled by such a test could have been settled with much less expense within 10 miles of the factory. Possibly, part of the fault is with the management. If the engineer could get a reasonable vacation by other means, he might be able to see how to get along without road tests crossing so many state lines.

Theory and Practice

A common criticism of the scientist is that he is too theoretical. The criticism is doubtless justified. But many engineers are more theoretical and it is usually the one who insists most on his practical viewpoint who is the most theoretical. A theory is simply an explanation for a fact or a group of facts. As a general proposition, the more facts a theory explains, the better it is as a theory. About 2000 years ago, the average man had a theory that the earth was flat. This explained the fact that it looked flat, and explained very little else. More than 2000 years ago, a Greek philosopher at Alexandria had a theory that the earth was round. This theory explained several facts to which the ordinary man gave but little consideration, such as the rising of an object above the horizon as one approaches it, and the rising and the setting of the sun. By having measured the lengths of shadows at noon on the same day at two points on a north-and-south line, he computed the polar circumference of the earth to a very high degree of accuracy. It does not seem reasonable to say that the philosopher was more theoretical than the common man so far as their ideas regarding the scope and the size of the earth were concerned.

Not all the engineers are yet dead who once had a theory that a hotter spark increased the power of an engine. This theory explained the fact that a weak battery with the old-style vibrator-coil sometimes led to a condition where an engine overheated and lost power. Everyone of these engineers who used this theory to explain a fact that they had seen, or heard of, on good authority, would have denied indignantly that it was in any way a theory, or that they reasoned theoretically. A theory that simply explains some known facts may be interesting, but it is of very little value unless it enables one to project forward and say that, if this theory is true, then some as yet unknown fact must be real. This suggests at once that a test can be made to determine the existence of the supposed fact. The test is then made, and something more is learned at once. The results of the test may confirm the theory, which is then stronger than ever, and we have as a by-product of the study a new proved fact. The results may be opposed to the theory and we are on the way to a correct theory.

A beautiful example of this type of thing has led up to the recent theory of Einstein regarding relativity. From the days of Newton until early in the last century, scientists discussed the nature of light. Finally, the wave theory seemed to win and, as a result of this and of Faraday's work on electricity and heat, Maxwell developed his theory of the luminiferous ether, through which light waves could travel. This suggested that, if delicate enough measurements could be made, enough difference in the speed of light could be detected under certain conditions of measurement to determine how fast the earth is traveling with respect to the ether. Michelson and Morley, and later Morley and Miller, made the attempt and failed to find the difference in the velocity. Einstein took this fact and simply postulated that light always travels in a given medium at the same velocity and, by mathematical deduction, worked out his theory of relativity. As a result of his mathematics he announced his theory according to which three things would follow: First, the major axis of the orbit of the planet Mercury would revolve at a certain very slow rate. It is known that it does revolve at a rate very close to the requirements of Einstein's theory. Second, a ray of light will bend in a gravitational field; that is, when it passes close to a large body like the sun. Third, the rays of light originating on a large body like the sun will have a very slightly longer wave-length than the light rays given off by the same substances on the earth. To settle the second prediction, photographs of stars apparently close to the sun are taken during solar eclipses. Three years ago, two expeditions succeeded in getting one photograph that seemed to confirm Einstein's theory. More photographs were attempted last summer, but all of the reports are not in.

Astrophysicists are not only taking new spectrograms of the sun, but are studying old ones in an effort to settle the third prediction. This effect is so small that other effects such as solar cyclones and varying pressures may easily cause greater effects, and many American students are skeptical that Einstein's third prediction is correct although some Germans say it is.

In the long swing of the progress of knowledge it makes no difference whether Einstein is right or wrong. He has stimulated the scientists of his time tremendously, and we shall not only learn much about conditions on the sun and about astronomy but also considerable about the chemistry of the photographic plates and their behavior during development, before the effect of this stimulus wears out.

When the scientist discusses our civilization of today, he is inclined to claim most of the credit for the rapid advance in material comfort and control over nature that has come in the last 150 years. Engineers make the same claims for their profession, pointing out that our civilization is based on modern methods of production, transportation and communication that are under immediate control of the engineer. As a matter of fact, the result we have is due to the combined efforts of both, the scientist being sometimes ahead of the engineer and sometimes the engineer has preceded the scientist who

has explained, after the success of the engineer, just why this success has been possible. The engineer preceded the scientist in early history; the pyramids of Egypt were built without the aid of the theory of structures. The Romans ruled the world at one time because their engineering of warfare, of communication and city organization was better than that of the opposing nations.

Power Necessary for Progress

The beginnings of our recent rapid progress came with a supply of mechanical power. Watt developed the steam engine without the aid of a scientific theory of thermodynamics. We must concede, however, that he succeeded where others had failed because he was the first to make measurements that were sufficiently accurate to enable him to improve his designs. He made and used the first steam-engine indicator, and worked in what must be admitted to be a scientific manner. The development of the steam engine not only gave a source of power for production, but also gave a source of power for transportation; and the railroad and the steamship were developed into a working form without the aid of the scientist. The scientist has, of course, contributed immensely to the improvement of these engines of civilization. The internal-combustion engine, however, was not developed into a practicable form until after a theory of thermodynamics had been developed; and most of the improvements in it have been due to the application of scientific principles. The whole foundation of our means of communication, however, was laid by the scientist, the engineer developing the leads found by the laboratory man. Faraday discovered the laws of electromagnetic induction. Henry worked out the laws of the electromagnet. Morse, the inventor, developed the telegraph; Bell, a scientist, proved the possibility of the telephone. The engineer, taking these devices and further information from the scientist, has made it possible to get prompt communication from one end of the world to the other.

The development of wireless communication gives two examples in which the engineer has stepped in advance of the scientist. Faraday collected evidence that heat, light and electricity, have certain close relationships. Maxwell developed a theory tying these together. Hertz demonstrated the existence of electrical waves following the same fundamental laws as light and Marconi, as an engineer, applied the science of Maxwell and Hertz to secure the wireless transmission of signals. After some preliminary success, Marconi decided to attempt to send messages across the Atlantic Ocean. According to the theory of science at that date this was impossible, because the wireless radiation, proceeding in straight lines, would not follow the curvature of the earth. According to theory there would be a certain fringing effect in the same way that light from a point source causes a shadow with a small fringe, but this effect would be too small to permit reception over more than a small part of the distance. Nevertheless, Marconi sailed across the Atlantic Ocean, receiving signals from England, and succeeded in sending detectable signals 800 miles by day and 1200 miles by night. Consequently, the scientists have had to work out a new theory. For a time, wireless seemed to stand still until another fact, found by another man who would not admit that he is an engineer, was used.

Edison's opinion of engineers is too well known to require further discussion, but his work falls inside the definition of engineering we laid down as a basis of our discussion. Edison noticed that if an electrode were mounted in some of his early incandescent lamps, a current would flow from the filament through a galvanometer to the third electrode when the filament was hot, the electrode being negative. This occurred without any apparent connection between the filament and the electrode inside the lamp. He followed this idea far enough so that he took out a patent before 1890 covering a wireless system involving this principle. The patent specification indicates that he had sent signals in a laboratory. It also shows that the idea of tuning was not known. This required some preliminary work by scientists, although as a matter of fact, the basis was all laid at this time. Years later Dr. Fleming, a scientist, who assisted Marconi, took advantage of the Edison effect, as it was called, and produced the Fleming valve for use as a detecting device. DeForest improved the idea by the addition of a third electrode in the bulb, producing the audion that is a still better detector. A large number of experimenters took the three-electrode tube and brought the wireless art to the position it occupies today. This whole wonderful device is founded on the work of scientists, and its development is principally due to scientists, yet we have two discoveries of vital importance coming first from engineers.

Predictions

Prophecy is an exceedingly dangerous thing. Rowland was probably the foremost American physicist of the past generation. When at the height of his reputation, he made the prediction that the work of the physicist of the future was to consist of rechecking the work of his predecessors and improving their accuracy and determining the constants such as the velocity of light to more significant figures. In his opinion, the fundamental discoveries were all made. Immediately after this the negative particle of electricity that we call the electron was discovered, leading directly to the discovery of X-rays, and to facts regarding the constitution of matter of such vital importance that the physicist and the chemist of today have an entirely different picture of the nature of the universe from that held by Rowland. If the best physicist of his time could be so far wrong, the danger to an engineer of prophecy is obvious, but two predictions will be risked.

One of the most important contributions of the scientist in the past has been new materials, or old materials improved so that they are entirely new for engineering purposes. The present generation of automobile engineers has seen aluminum develop from an expensive material that hardly could be called a metal, so far as its physical properties are concerned, except for the fact that it could be cast, into a material that can be produced as strong as mild steel and that can compete with steel on a cost per result basis. Pure tungsten was practically unknown 20 years ago and, when first produced, it scarcely could be put into a form where it could support its own weight. Today, the tungsten wire in lamps having the finest filaments has a tensile-strength of over 500,000 lb. per sq. in. This again is the result of the work of the scientist. With such examples of past contributions of materials, we confidently can expect more in the future.

Another contribution of great importance that the scientist will make to the engineer in the future is the scientist's method of working. The only reason the scientist has not made this contribution already is because the average engineer has not been ready to receive it. The scientist analyzes his problems, divides the

(Concluded on p. 62)

Four-Wheel Braking Systems

AN important feature of the Semi-Annual Meeting of the Society held at Spring Lake, N. J., June 19 to 23, 1923, was the presentation of three papers dealing with the general subject of four-wheel braking-systems for automotive usage and the interesting discussion that followed. Three types of brake were described and commented upon by the authors of the three papers printed herewith, including one of the hydraulic type and two types of mechanical systems, the intention being the presentation of an unprejudiced symposium on the merits and demerits of four-wheel braking in its application to the motor vehicle. Two of the papers are printed below.

MECHANICAL BRAKING ON FOUR WHEELS AS A PRESENT AUTOMOTIVE NECESSITY

BY ALVIN M. YOCOM[1]

THE author states that, when used in conjunction with the braking effect of the engine, two-wheel brakes work well in retarding a car on long or heavy grades, but that, for emergency stops, which are by far the most frequent, two-wheel brakes do not give a driver the positive control of the vehicle and the sense of security that are imparted by the retarding effect of braking on four wheels. The mechanical four-wheel braking-system manufactured by the company the author represents is described and illustrated, the claim being made that the front-wheel portion of the system can be connected and equalized with any of the present-day rear-axle or transmission brakes without discarding any of the rear-axle or transmission brake-material. The equalization of brakes is discussed in some detail, inclusive of foreign practice, and other features such as "fight" in the brake-pedal, the mounting of the steering-arms and the distribution of shoe pressure to prevent chattering and "grabbing" are considered.

WITH regard to the possibility of reducing car weight and complication by removing the brake rigging from one truck on each railroad car, a railroad maintenance official would say immediately that it would be impossible to do so and maintain present railroad schedules safely. Further, he would state that the wear due to braking on one-half of the normal braking surface would cause such a rapid deterioration of brake mechanisms that using this type of construction would not be a sound policy economically. Per pound of load, railroad equipment is much heavier than that used for motor transportation, but most of the braking in railroad service is done at predetermined points; motor vehicles are manipulated under exactly the opposite condition. To miscalculate by a fraction of a second often means a crash; grades are steeper, acceleration is faster and frequently two cars are each driven directly into the path of the other.

Used in conjunction with the engine, two-wheel brakes work very well in retarding a car on long or heavy grades but, for emergency stops, which are by far the most frequent, this method is impractical and two-wheel brakes do not give the driver the positive control and the feeling of confidence and the sense of security that are imparted by the retarding effect of braking on four wheels. The company I represent has evolved the design shown in Fig. 1 after a number of years of study, experiment and production of four-wheel brakes.

Two shoes inside of the drums are expanded by toggles

[1] M.S.A.E.—Chief Engineer, U. S. Axle Co., Pottstown, Pa.

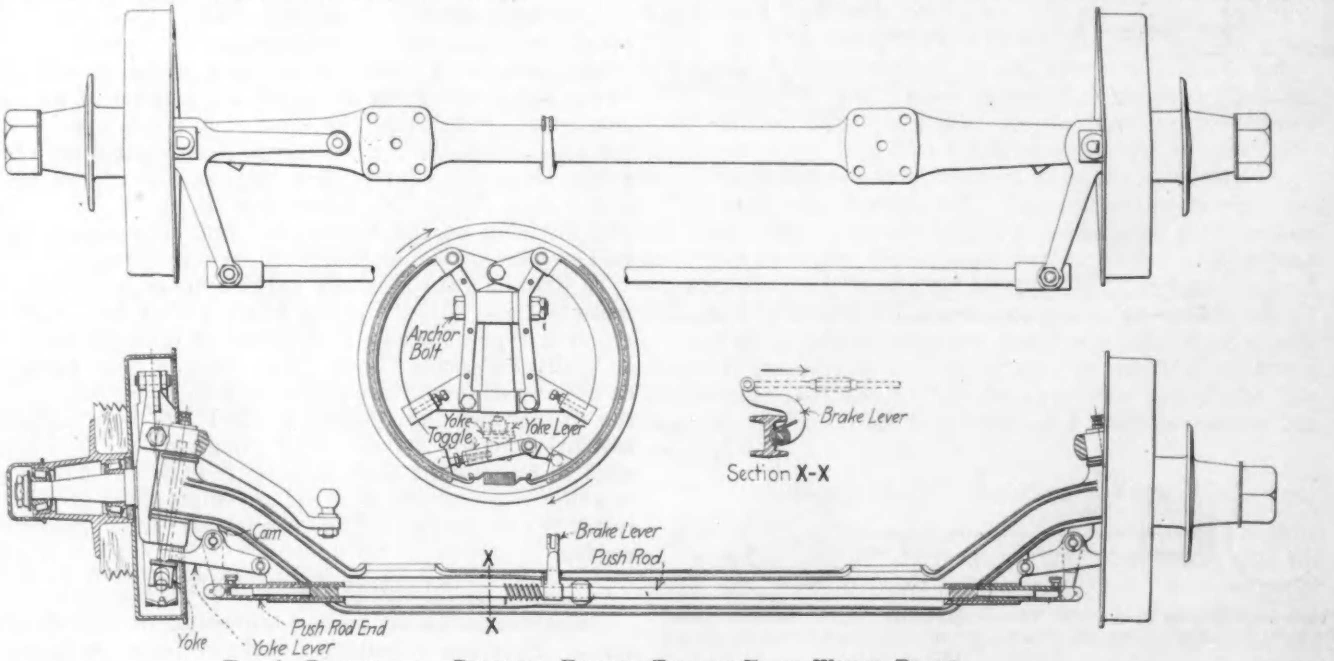


Fig. 1—Details of a Recently Evolved Type of Front-Wheel Brake

and the toggles in turn are expanded by the moving down of the yoke. The yoke is moved by the fingers, which are actuated by a cam that bears against the beam. The cam ends are moved outwardly by threaded sleeves, which are actuated by rotating a rod. The rod is rotated by a brake-lever connected with the brake-pedal. The front-axle brakes are equalized by the rod in this manner, and the threaded sleeves float between the cam ends. The connection between the cams and the sleeves is such that any beam deflection causes a sliding action between the threaded sleeves and cam ends and destroys any tendency to bind.

This type of front-wheel brake can be connected and equalized with any of the present-day rear-axle or transmission brakes without discarding any of the rear-axle or transmission brake-material. Fig. 2 shows the mode of connection with the rear-axle brakes. Fig. 3 shows a typical layout, illustrating the connection between the transmission brake and the front-wheel brakes.

Equalization

In further reference to Fig. 1, if a cam be used to expand the brake-shoes, the latter must be machined accurately and the brake-lining mounted without a pucker between the rivets. If this work is not done accurately, one shoe will make contact with the drum and the other shoe will not; the result is low braking efficiency. This toggle type of expander is self-centering; if one shoe makes contact before the other, the reaction of the contact of one shoe forces the other shoe into place; thus, compensation is made for any machining or lining inaccuracies that may occur.

This reaction idea is carried out fully also in equalizing one front-wheel brake with the other. If one pair of shoes makes contact before the other, the threaded sleeves and the rod immediately slide toward the non-contacting shoes and force them into position. With certain modifications, this sliding-rod construction can be used also for equalizing the rear-axle brakes. If this type of design is used in both front and rear axles, one

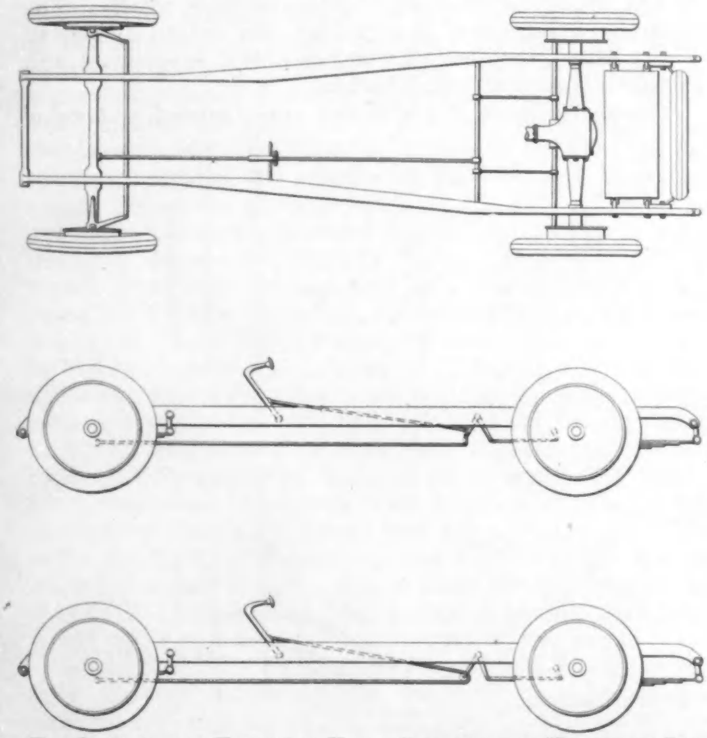


Fig. 2—Plan and Elevation Views Showing the Method of Connecting the Front-Wheel Brake with the Conventional Rear-Wheel Type

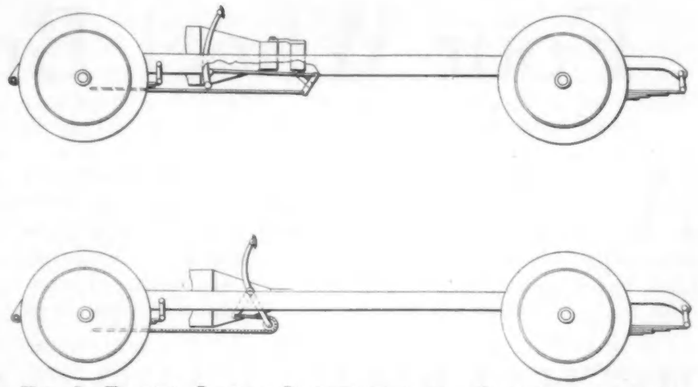


Fig. 3—Typical Layout Illustrating the Connection between the Transmission and the Front-Wheel Brakes

actuating rod from the front axle and one actuating rod from the rear axle to the brake-pedal are all that are necessary to apply the brakes in four drums; less length of actuating rod is used to apply four brakes in this manner than is now used to apply two-wheel brakes.

Foreign Equalization Practice

Many foreign designers use two lines of rods and several equalizers. Close study of their layouts discloses the fact that, due to frame distortion, spring deflection and the use of cam action, it is possible to have one shoe making contact in one front drum, one shoe making contact in one rear drum, and the other six shoes not even touching the drums; of course, as the wear in the two shoes progresses, the other six shoes finally take their place. Let us assume now that all shoes make contact, but that loading, heat and moisture cause an uneven swelling of the lining or a distortion of the shoes, the drums, the frame and the springs. These factors cause further trouble, and the brakes do not hold properly; again, all the shoes are not making contact and they must wear-in to compensate for these added conditions. Therefore, braking conditions vary continually.

Types of Construction

The use of a full-reacting type of construction is the best assurance that eight shoes or four bands will make contact with the drums from the time the brake-linings are renewed until they are worn thin. It is the one construction that wholly compensates for production and other deforming inaccuracies and gives a reasonable brake equalization regardless of the manner of brake adjustment. A full-reacting type of brake is one in which the reaction of the contact of one shoe must force the opposite shoe into contact, and the reaction of one pair of shoes must force the other pair of shoes into contact. The reaction on the front-brake pull-lever must exert a pull on the rear-brake pull-lever, or vice versa.

In driving over a rough surface there will always be more or less "fight" in the brake-pedal; but, with this reacting type of brake, each pound of pedal pressure will be multiplied many times, eight shoes or four bands will be expanded almost simultaneously to be in contact with the drums and the retarding effect will be a delightful revelation to the driver. Over rough roads, it is impossible to force eight shoes against four drums unless full-reaction construction is used; anything short of this will result in uneven wear of the lining and faulty unequalized brakes.

Steering-Arm Mounting

Attention is called to the mounting of the steering-arms. They are yoked over and reinforce the steering-

knuckles. The connection of the steering-arms and the steering-knuckles is made inside the drum-covers. This makes the clean construction that is so desirable on the front wheels. Bolt-heads and uneven drum-covers give a clumsy appearance to front-wheel brakes. The brake-anchors are secured by the same bolt that clamps the arms, but it holds both arms and knuckles in such a manner that it is not directly stressed by either member. This construction is very simple, accessible and easily dismounted.

Reinforcement and Steering Ability

There is always a tendency to fracture the steering-knuckle just outside the steering-pivot bearing. This part is strengthened by carrying the brake-anchor down and bolting it fast to the steering-knuckle, thus giving the knuckle a much higher factor of safety. The steering-arm knuckles and brake-anchors are grouped to reinforce one another and this results in a unit that is not only light in weight but also strong in its construction.

If the front wheels are retarded to such an extent that they cease to rotate, the driver is unable to steer. To eliminate this danger, the operating yoke is arranged so that it makes contact with the toggle-bar on a skew; this causes a lighter pressure on the shoe that tends to wrap into the revolving drum than it does on the shoe that tends to be forced away from the revolving drum. This distribution of shoe pressure gives a surprisingly smooth but positive retarding effect, and the danger of chattering and grabbing of brakes is wholly avoided.

Although many of the present two-wheel and transmission brakes are very efficient, an automobile cannot be brought to a standstill with the rapidity with which an electric car or railroad train is decelerated. Numerous accidents point to the necessity of better brakes. If all that possibly can be done has been done to create the best rear-wheel brakes, the next step is the adoption of a simple dependable four-wheel-brake system.

THE RENAULT MECHANICAL FOUR-WHEEL BRAKING-SYSTEM

BY MARCEL GUILLELMON[2]

THE high car-speed demanded by present-day drivers of automobiles is stated by the author as having necessitated braking systems that more adequately overcome the effects of such increased momentum than is possible with ordinary brakes applied only to the rear wheels. Since, at the time the brakes are applied, the greatest part of the weight of the car is thrown upon the front axle and the front wheels, he believes it imperative that brakes be applied also to the front wheels and demonstrates that this also prevents skidding as well as increasing the braking effect.

The four-wheel braking-system of the Renault car is then illustrated and explained in detail, and the advantages of this servo-brake system in regard to braking power, smoothness of operation and adequate car control, are set forth.

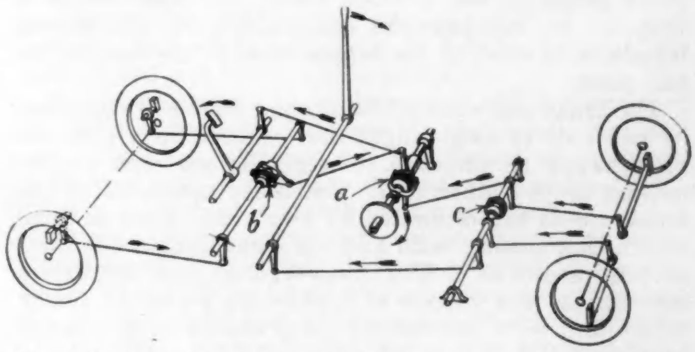


Fig. 4—Diagram Illustrating the Arrangement of the Renault Four-Wheel Brake-System

OWING to the public demand for high speed and the consequent greatly increased speed-ability of present-day motor-cars, braking systems that adequately overcome the effects of such increased momentum become an imperative necessity. At car speeds of more than 40 m.p.h., I believe it to be unsafe to attempt to stop a car quickly if it is equipped only with ordinary brakes that act solely upon the rear wheels. In fact, it is abnormal to exert the retarding effort only on the two rear wheels because, at the time the brakes are applied, the greater part of the weight of the car is thrown upon the front axle and front wheels. Besides that, when the ordinary brakes are applied too suddenly to the rear wheels, the car has a tendency to skid laterally. Therefore, brakes should be applied also to the front wheels, since brakes applied solely to the two rear wheels have proved to be insufficient.

In 1921, Baudry de Saunier, the editor of *Omnia*, Paris, France, showed very positively that front-wheel brakes will prevent skidding. To demonstrate the method of proof, I will use a small toy automobile and place it at the top of an inclined surface that represents a steep grade, such as an inclined sheet of stiff cardboard. If the driving wheels of the car are in normal position and can travel in a straight line, the car will run rapidly down the inclined surface. Now let us make the same experiment and lock the rear wheels. Then we will notice that, as the car runs down the incline, the rear end skids slowly and that the car turns through a semicircle until the rear wheels occupy the position that the front wheels had originally. If we now make a third experiment and lock the front wheels, the car will descend the incline slowly without skidding around.

The experiment made with this miniature car can be repeated with a full-size car that is equipped with brakes on all four wheels. When applying the brakes on the rear wheels only, if the car is running on a greasy road it will skid laterally; on the contrary, if the brakes on all of its four wheels are applied simultaneously, the car will stop without any lateral skidding. In addition to other advantages, brakes on all four wheels distribute the braking power on all four tires and thereby reduce the wear of the rear tires.

The Renault Braking System

The 18-30 hp. and the 40-60 hp. Renault cars are furnished with two sets of brakes. The hand brake acts directly upon the driving wheels only, but the foot-pedal brake exerts its retarding effort on all four wheels simultaneously. In each of these two braking systems, the operation is through internal expanding shoes in drums

[2] Vice-president, Renault Selling Branch, New York City.

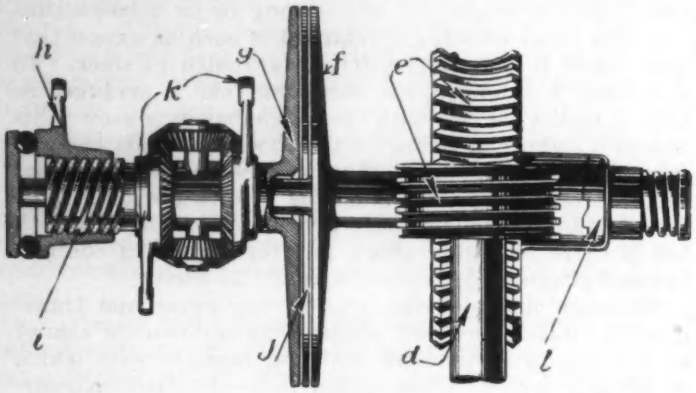


FIG. 5—DIAGRAM OF THE VARIOUS PARTS OF THE SERVO BRAKE

fixed solidly on each wheels, the shoes or segments being expanded by the angular displacement of a cam.

Fig. 4 is a sketch showing the layout of the servo-brake. It has three differential compensators. The main differential compensator, *a*, is used to equalize the retarding effort on the two front and two rear sets of brakes and it controls the two other differential compensators *b* and *c*, which equalize, in their turn, the braking force that is applied to the individual wheels. The main differential compensator, *a* and that which equalizes the front group, *c*, are situated under the floor-boards in front of the gearbox; the compensator for the driving wheels, *b*, is fixed on the torque tube, to the rear of the ball joint.

The brake cam-arms of the driving wheels are operated by two rods of fixed length that connect them with the compensator shown at *b*. These rods are each supplemented by two other rods. The brake cam-arms of the front wheels are connected by two steel cables of fixed length that connect with and are controlled by the compensator shown at *c*. The brake-segment rods and cables between the two groups of brakes are regulated finally before they leave our factory; *they should on no account be altered.*

PRINCIPLES OF THE SERVO-BRAKE

Since the foot-pedal brake actuates the entire braking surface on all four wheels, the braking effort exerted on each wheel is always in accordance with the amount of resistance, or road-grip, of the wheels concerned.

Taking into consideration the great weight of the modern cars and the high speeds at which they travel, the physical strength of the average driver is not sufficient to apply the necessary force needed to obtain the maximum braking power. A normal man can only exert a force of about 130 lb. on a brake-pedal, and this allows for only about 45 lb. on each brake-drum. It is impossible to increase this pressure very much by levers and linkage, because the movement of the brake-pedal is limited to say 10 to 12 in. of travel. Further, at speeds of more than 35 m.p.h. the power needed for each brake-drum should be at least four to five times greater than the power a driver is capable of exerting. But the servo-brake system makes it possible for a driver to exert a very great braking pressure on each of the four brake-drums with very little effort.

FIG. 6—ADJUSTING THE SERVO BRAKE

This small amount of effort needed in the application of the servo-brake is due to the fact that the system derives its energizing effect from the movement of the car itself; therefore, it is obvious that the driver can obtain a very powerful braking force with a minimum amount of effort.

The hand-brake lever is moved alongside a ratchet, which can be regulated or set to produce the amount of braking effort required; to release the hand-brake lever, it is sufficient to raise the trigger from the ratchet tooth. This hand-brake lever first operates the differential compensator, *b*, in Fig. 4, and this equalizes the braking effect on each of the driving wheels.

SERVO-BRAKE DESCRIPTION

The construction of the servo-brake is illustrated in Fig. 5, as well as the relations the parts bear to one another. The principles of its operation will now be described, by following in detail the manner in which the foot pedal functions.

The propeller-shaft *d*, running direct to the driving wheels, is connected through a worm and wormwheel, *e*, with the plate *f* of the servo-brake and revolves with it; therefore, it turns at a speed that is strictly in accordance with the speed of the car, but one much slower than that of the propeller-shaft. The second plate, *g*, is mounted upon a shaft so that it can be displaced longitudinally along the axis of the shaft, toward the plate *f*. Under the action of the brake-pedal, the rod to which it is connected moves the nut *h* which, in its turn, rotates the worm *i* in the same direction and thus controls the movement of the plate *g* axially. A "ferodo" disc, *j*, separates the two plates *f* and *g* in a manner similar to that used in clutch construction; when the brake-pedal is actuated to apply the brake and causes plate *g* to move toward plate *f*, the tendency is created to cause the plate *g* to rotate with the plate *f*; then, through the action of the compensating differential and its levers, *k*, the braking pull originating at the brake-pedal, which obtains added power due to the action of the plate-clutch *f g*, is communicated to the brakes.

SERVO-BRAKE ADJUSTMENT

The "give" in the brake-pedal indicates the amount of play between the three discs *f*, *g* and *j*, in Fig. 5. When the ferodo disc *j* wears sufficiently, it is necessary to take-up this wear. The process of doing this is illustrated in Fig. 6. The two pins that hold the inspection plate *m* are removed, together with the plate. Then, with a punch, *n*, the collar *o* is turned in a clockwise direction according to the limit of the brake-pedal action, until no play exists between it and the controlling nut. The nut is then unscrewed one-quarter turn, corresponding to three divisions of screw holes. If, when this adjustment has been effected, the brake-pedal moves of its own accord, this is an indication that the servo-brake

has been adjusted too close; that is, the certain amount of play which is absolutely necessary between the three plates *f*, *g* and *j*, in Fig. 5, is not sufficient. It is then necessary to unscrew the adjusting nut another one-quarter turn.

Adjustment of Wheel Parts

As shown in Fig. 7, each brake-arm on the wheels of the car is fitted with an adjusting system composed of an endless screw that terminates externally in an hexagonal head, *p*, in conjunction with a toothed wheel that is solidly connected with the cam-arm *q*. The "taking-up" of the excess of play that might exist between the brake-shoes and the drums is accomplished by turning, in a counter-clockwise direction, to the extent of one or several teeth, the heads of the endless screws; the number of these turns must be exactly the same for each wheel, that is, to the extent of an equal number of teeth.

The adjustments having been made while the car is stationary, it should then be jacked-up completely and all of the car wheels should be rotated. If it then proves impossible to rotate the car wheels, the brakes are adjusted too hard and the four adjusting screws should be unscrewed to an extent that is *exactly the same number of turns for each screw.*

Hand Brake and Lubrication

When the hand-brake lever has been disconnected, the levers connecting it with the differential compensator should just protrude from the back of the case enclosing their upper parts.

The servo-brake should be lubricated with thick oil after every 600 miles of car travel. This is done by unscrewing the cap provided and refilling the reservoir to the indicated level,

Braking While in Reverse

A distinctive and important feature of the Renault servo-brake is that the driver can use his foot-pedal brake while the car is standing or goes backward. Again referring to Fig. 5, the shaft that carries the plate *f* carries also a ratchet device, *l*, the object of which is as follows:

The device remains idle when braking is being done while the car is traveling forward and during moments when the full braking force is required, but it permits braking when the car is stationary or in reverse gear; when the car is going backward, the plate *f* is free;

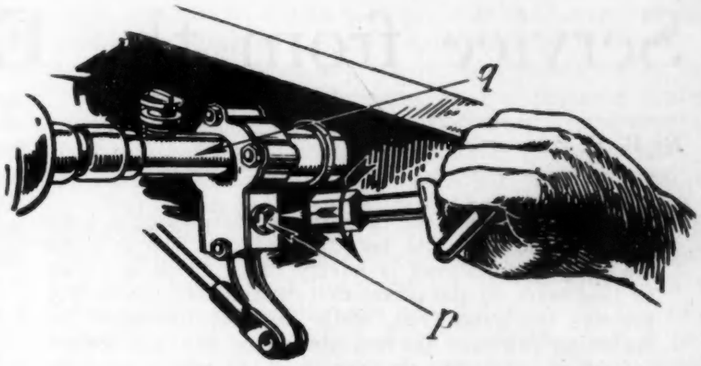


Fig. 7—Adjusting the Wheels

because the ratchet device *l* operates. The brake-pedal causes the nut *h* to actuate the mechanism; the discs *f* and *g* rotate together because of friction, but they turn together independently of the propeller-shaft and as if the mechanism comprising the parts *h*, *i*, *g*, *f* and *k* constituted a set of compensating levers. It is true that in this instance the braking power is less than when the car is traveling forward but, in reverse gear, this more moderate braking power is wholly sufficient.

Operative Smoothness

In further reference to Fig. 5, the plate *f* turns at far less speed than that of the propeller-shaft *d*. In this manner, the heating effect due to friction between the plates *f* and *g* is reduced to a minimum.

Due to this reduction in plate speed and the extent of the friction surfaces, the wear on the ferodo disc *j* is very slight and a remarkable smoothness of operation is attained that is especially evident when making quick stops of a car that is traveling at high speed.

With the more perfect car control attained by using brakes on all four wheels that are actuated by a servo-brake, it is safer to travel at high speed and, therefore, the average speed that can be maintained is very much greater. This is also of advantage in city travel, through congested traffic, which necessitates continual stopping and starting.

After one has become accustomed to the use of four-wheel brakes on a car, to ride in a car equipped only with rear-wheel brakes gives one the same feeling of uncertainty that would be felt if one were to ride on a railroad train at express speed and knew that the train was not equipped with airbrakes on all its wheels.

STANDARDIZATION SAVING IN DOLLARS AND CENTS

The $2,000,000 possible reduction in armature stocks estimated by A. H. Packer in his paper on Maintenance Effects on Automotive Electrical-Equipment Standardization, presented at the Chicago Service Meeting and published on p. 283 of the March issue of The Journal, raises points of much interest in connection with the maintenance of motor vehicles. The Society has standardized electrical-equipment mountings and the standards have been adopted in practice to a certain extent. The plans of the Automotive Electric Association, in furthering standardization, to establish standard sizes of generators and starting motors, warrant careful consideration by the industry. Standardization affecting the internal design of electrical apparatus is not considered desirable, but interchangeability of electrical units of different makes, as well as the reduction of sizes to the number of stock sizes of the units, could and should be attained.

CUTTING TESTS OF HIGH-SPEED STEEL

Five types of steel are to be considered in the investigation which is being conducted at the Bureau of Standards, and the second steel of the series has been heat-treated for the first set of tests in which hardening temperature is the variable. In connection with this work a number of treatments were applied to a single heat of high-tungsten low-vanadium steel to determine whether so-called fish scale or flaky fractures could be produced intentionally irrespective of the quality of metal as has been claimed. Normal fractures were obtained, however, in all cases, but these tests will be supplemented by further work with steels of questionable quality. The question was brought up for discussion at a recent meeting of the American Society for Steel Treating at Rockford, Ill.

Service from the Engineer's Viewpoint

By B. B. Bachman[1]

Metropolitan Section Paper

After outlining the operation of developing a piece of apparatus and pointing out that the analysis made by the designer is hardly likely to be as exact as that made by the production department, the author stresses the point that, while in some instances the designing engineer has laid himself open to the charge of being arrogant, the service-man is not entirely blameless by reason of the impetuousness with which he makes and supports assumptions. For a designer to make and maintain personal contact with a large number of dealers is a difficult task.

In discussing the flat-rate system of service charges the author states his belief that undue merit had been claimed for the system and emphasizes the fact that it is not the only method which can be made satisfactory to the car-owner. To be acceptable to the customer the price charged for repairs must appear to be fair and have as its basis an accurate method of determining the cost. Some flat-rate prices for service repairs of the most ordinary character are obviously unjustifiable. As opposed to these objections, the flat rate system is valuable in that it necessitates a careful analysis of the various operations. After commenting upon the variation in labor and time that sometimes results from the difference in individual conditions on the same class of job, the more serious matter of the variation in the amount of material required to do a first-class job under different conditions is brought out. In the author's opinion such variations cannot be properly provided for in the flat-rate system, with the inevitable result that the owner who is careful of his car is overcharged, while the one who gives less thought to the car's condition escapes with an undercharge.

In conclusion the thought is expressed that little or no demand has existed for economical transportation by automobiles as opposed to cheap vehicles and that a product based on the former demand would, in all probability, be a failure. However, in the near future the public will demand economy in automobile operation and this will be made possible by a number of factors, among which are the development of the highways, a widespread distribution of repair facilities, an increased knowledge of mechanical things and a greater ability to form a judgment as to true values.

The need for service in the automotive field is such a self-evident proposition and has been commented upon so frequently that it seems unnecessary to do other than to indicate that I thoroughly appreciate its importance. It would seem to be inconceivable that of all the individuals interested in the automotive industry, there should be any that could more correctly appraise the value of close cooperation with the service organization than the engineer.

The operation of developing any piece of apparatus appears to be about as follows: The designer, having obtained information as to the purpose of the apparatus and a conception of the conditions under which it is to function, will lay down a design based upon his experience. First, it will be necessary for this design to pass the criticism of the manufacturing organization, particularly with regard to the intricacy of the various parts and the difficulties that an examination of the design indicates may be encountered in the pattern shop, the foundry or the forging department, as well as in the machine shop. At a later date, the design, either in embryo or in completed form, will be passed upon by the selling organization.

This analysis is hardly likely to be as exact as the production analysis. It is a matter of record that designs which were met with the most violent disapproval have, by their merit, proved successful. The relatively few cases, however, in which this is so are merely an indication that the factors entering into this particular part of the problem are not so susceptible of being given a definite quantitative value. It has been assumed in this hypothetical situation that there is no service department for the particular device in question, and this has been done purposely simply to point out that whether there be a service department or not, after these other analyses have been made during the period in which the design was being created, the final test of the suitability of the device is the service rendered in return for the price that is asked for it. The man responsible for the design, by whatever name you may call him, if he realizes the responsibilities that he must assume, cannot fail to recognize that it is only by observation of the manner in which the device meets the practical requirements of the user that he can check up the soundness of the original theory on which the device was developed.

Cooperation of the Engineer with Other Departments

It seems to be so self-evident that the engineer should put himself into sympathetic relations with all the various branches of the production organization, the sales organization, the accountants and the service department in order that he may properly develop any mechanism for which he is responsible, that I can do no more than most heartily endorse any reasonable suggestion for cooperation between the various individuals. There can be no possibility of excuse for the engineer not taking into consideration service reports, no matter in what form they come to him. It is only human nature that those suggestions which are presented in a helpful manner are most pleasant to consider. Recognizing this fact does not establish an excuse for neglecting to pay attention to information that may come in the form of querulous complaint.

With regard to details as to how this cooperative relationship shall be best established, it is exceedingly difficult to outline a method that will cover all requirements. It is obvious fundamentally that, as with most other things, personal contact is the most efficient method. It is, however, to be recognized that it is too much to expect that the service reports will always be complete and accurate, or that the recommendations made should always be followed blindly. Where the engineer can be justly criticised for his cold arrogance, the service-man can frequently be criticised for the impetuosity with which he makes certain assumptions and supports them. It must moreover be recognized that very frequently reports from two different service-stations are in direct opposition to each other; or it may be that alterations desired by the service department

[1] M.S.A.E.—Chief engineer, Autocar Co., Ardmore, Pa.

conflict with design requirements as dictated by the sales or the production department. The engineer is therefore placed in a judicial position in which it is necessary for him to exercise his judgment in determining which of the conflicting viewpoints should be followed. Under such circumstances, it is probably not unnatural to suppose that the opinion of the engineer's ability and judgment will be lower in the minds of the individuals whose opinions have not been followed than it is in the mind of the one whose recommendation has been adopted.

This situation is, of course, another excellent argument for the establishing of those personal relations that always foster confidence between the engineer and the service organization, particularly. I think it is also worth taking into consideration while we are discussing this subject that it becomes a real man's job to get into and keep in personal contact with the multitude of dealers who form the service and selling organizations of many of our most widely sold cars. There are numerous ways in which the engineer can avail himself of information obtained from the service-station. It is unfortunate, however, that most of these methods depend for their highest efficiency upon personal study and interpretation. Where an exceedingly large volume of reports are received and must be digested, it becomes impossible for one man to handle the details. I have found it exceedingly difficult to train junior engineers to take the necessary critical pains in analyzing reports.

Objections to Flat-Rate Service-Charges

The flat-rate system of service charges has been discussed at great length and, while I believe that such a method possesses many features of merit, I am convinced that merits are imputed to the system which it will be hard to justify on careful analysis. One of these is the statement that the flat-rate system is the only method that will succeed in bringing the customer into a satisfactory frame of mind with regard to paying the bill. It seems that to have the price for work done acceptable, several things are necessary. First, the price must represent in the buyer's mind a just charge. I think that we can all point to a number of service jobs on an automobile where, even with the best of accessibility and with the best of facilities, the cost of a repair to the unskilled mind is out-of-line. These few cases can undoubtedly be adjusted by an explanation that will appear reasonable to the majority of men.

The second requisite is that the charge for the service performed be based on an accurate method of determining the cost, and this is not nearly so easy a proposition to determine as it might appear on the surface. I submit that if the service-man knows his costs and thereby establishes a fair price for the work that he performs he can obtain the confidence of his customer. Some flat-rate prices for service repairs of the most ordinary character are, on the face of them, absolutely unjustifiable. It appears that whether the customer gets this price before or after the job is completed is of little consequence, except that the service-man might get one job to do in one case where he would get none in the other.

The big value of the flat-rate system lies in the necessity, in establishing such a system, of making a careful analysis of the operations and determining with accuracy and certainty the cost of the operation. Such a process is recognized to be indispensable in the conduct of any manufacturing business, and is equally important in the service department, although to date the need has not been so generally recognized. Due to many conditions, it has been possible for service organizations to survive on a hit-or-miss basis of price-making that would have been suicidal in the manufacturing end.

Therefore, if the advocates of the flat-rate system, instead of placing emphasis on the results to be obtained from the system, would more strongly emphasize the preliminary investigations that must be made and the general business housecleaning that must be done to establish the foundations upon which a successful flat-rate system can be based, their purposes would be better served. Outside of the variation in the labor and the time that may result from the difference in individual conditions on the same class of job in the way of parts that are frozen and thereby consume a large portion of time to remove, the matter of the variation in the amount of material required to do a first-class job under different conditions is more serious.

I have never been able to see how these variations could be properly provided for by the flat-rate system unless an overcharge were made in some cases and an undercharge in others as a result of the application of the law of averages in establishing a price. This in itself is undesirable and becomes more so when it is realized that with this system the man who is overcharged is the fellow who has been careful and taken decent care of his car, and the fellow who gets the benefit is the one who has been careless and neglected it.

The Automobile as a Transportation Unit

It has taken a long time, relatively speaking, for the automobile to be recognized as a transportation tool. The process is just in its beginning. In the infancy of the industry, the vehicle was looked upon largely as a sporting proposition. Reliability was hoped for but not expected, and, until later developments in carburetion, ignition and tires removed many of the original elements of unreliability and delay, was despaired of. This statement, of course, does not minimize the developments that were made in general vehicle design and of materials in their application to the structure. This development, together with that in production methods which made possible the wholesale duplication of units with the consequent lowering of first cost, has made possible the volume of distribution that the automobile has had in these recent years.

There has been a demand for cheap automobiles, but there has been little or no demand for economical automobile transportation, which is an entirely different thing; and it is extremely probable that the attempt to produce and market an automobile based on such premises would meet with commercial failure. The engineer has been thinking for years about economy in operation, and is in possession of pretty definite information of the lines along which designs should be laid-out to obtain this economy. It has never been possible, up to this time, to get these ideas into practical form because they would not have met with public acceptance. There is no question, however, that within a relatively short time an increasing public opinion will be coming into existence that will be favorable to and demand economy in automobile operation.

Numerous factors will make this possible. Among them may be cited the development of the highways, the very general distribution of repair facilities, an increasing knowledge concerning things mechanical and a greater ability to form a judgment as to true value. As these factors develop and make their influence felt and become the basis for a new theory and practice in design and construction of automotive apparatus, some

things will be brought to light that up to the present time have not received the careful consideration that they deserve.

The service-station and the repair-shop are valuable to the engineer today if for no other reason than the fact that, by studying the repair work that is required on present-day automobiles, a vast amount of experience can be accumulated upon which the car of the future must be built to survive. [The discussion of this paper is printed on p. 95.]

SCIENCE AND ENGINEERING

(*Concluded from p. 54*)

problems into their elements, studies the effect of one variable at a time and takes the utmost care to make sure that he is working with only one variable. The most successful engineers have approached this method more or less closely, but the average engineer does not do so deliberately and as a matter of general policy to the extent that he should, and to the extent that he must if he is to assist American industry to meet world competition as it will exist during the next 50 years. In the automotive industry, we assemble a new car with what we think are improvements in the engine, in the carburetion, in the ignition and in the riding qualities, and send it out on a road test. In spite of all the improvements, the fuel consumption in miles per gallon may remain the same. The improvements in riding qualities have increased the average speed enough to mask the other improvements. We are proud of our progress because we have learned to use the dynamometer so extensively in the last 10 years, but too many engineers proceed as though they did not believe anything implied in their dynamometer-test data. The road test is still needed to show us what to test in the laboratory, but usually we can determine the real relations between the quantities very much cheaper and much more accurately by varying one factor at a time, where these factors can be controlled accurately and the effect measured.

One of the advantages of living in Dayton is to have the privilege occasionally of watching visitors who go through the laboratory of Orville Wright, especially when these visitors hear the story of the first flight with mechanical power. We think usually of the solution of the problem of flight as an invention, as a revelation, granted to fortunate and gifted individuals. There is no doubt of the gifts of the individuals, but the striking thing is that this first flight was based on measurements made by scientific methods, even if only crude apparatus was available. These measurements were made after the previously published data were found to be inaccurate. The problem was solved by analyzing the factors involved, measuring the lift-drift ratio of different wing sections and different wing shapes, determining the elements of the problem of flight control and the necessary means for this control. We find the explanation for the fact that the Wrights learned to fly and never had an accident as a result of the failure of the powerplant, when we find that they analyzed the reasons for gliders going into tail spins and constructed a plane that could not go into a tail spin even if stalled.

All the facts regarding all inventions and discoveries would show that the results were obtained as the result of a more or less definite plan of investigation, and as the result of improved measurements, in many more cases than the public realizes. Science will give the engineer wonderful materials and wonderful processes in the future as in the past. Science can give the engineer today something that in the total will really be of more importance, a method by which the engineer can help himself, the scientific method of working. It remains for every engineer to decide how far he can make use of this method.

FRENCH COLONIAL EMPIRE

FRANCE has today the second greatest colonial empire of the world, and the French Government and people are proceeding with the development of their colonies in a manner calculated to command the greatest respect on the part of those who are really informed as to their plans and the methods employed in carrying them out. In the first place, nothing could be more impressive than the mere area of the present colonial system of France with its colonies, dependencies, protectorates and mandates in all parts of the world embracing today some 5,000,000 square miles of territory, or about 2,000,000 square miles more than the total area of the continental United States of America. The colonies of France are found in every quarter of the globe, though principally, of course, in Africa and Asia and predominantly in the tropic or the sub-tropic regions. It goes without saying, too, that a very wide diversity of races is represented in these various colonial possessions, calling for a high degree of administrative skill on the political and the social side of their government; while the economic problems implied by the vast range of the products of the different colonies and the possibilities of advantageous development they afford are such as to call for the widest knowledge and the greatest intelligence on the part of those charged with the duty of coordinating the colonies with France herself in an economic sense and of binding the numerous members of this great empire together in one interdependent and mutually serviceable whole.—*Economic World.*

SOCIETY MEETINGS

LARGE ATTENDANCE AT SPRING LAKE

Meeting Attracts 748 to Atlantic Coast Resort—Low-Pressure Tires Featured

The 18th Summer Meeting of the Society was a distinct success. The attendance reached a total of 748, which is only a little shy of the record for Summer Meetings since their inception. Blessed with ideal seashore weather throughout the meeting period, every feature of the program was run off without interruption or postponement. The papers presented at the technical meetings drew large and representative audiences, their engineering value and timeliness were commended and the discussions were productive of valuable opinion on the debatable points. The numerous exhibits and demonstrations aroused more than usual interest and needless to say, the sports program brought out a large field of recreation lovers.

The sessions and informal porch meetings seemed to reflect a preponderance of interest in the introduction of large-section low-pressure air-cushion tires for passenger cars. Everyone present agreed that the advantages of this new equipment were sufficiently attractive to warrant a very thorough study and trial of the new tires to overcome the disadvantages that were cited against them. Some 10 or 12 demonstrating cars were provided at the meeting for the purpose of giving the members first-hand impressions of the improved riding quality resulting from the use of air-cushion tires, and these cars were in constant demand for curb-climbing and rough road demonstrations. It is evident that the tire engineers are not in complete agreement among themselves on the final design practice that will dictate sectional dimensions, air-pressures, rim widths and sections and other important fundamental data. They did reflect an optimistic attitude toward the eventual development of satisfactory low-pressure tires provided they can secure the full cooperation of car engineers in altering spring, steering and chassis design to take the utmost advantage of the air-cushion principle.

Four-wheel brakes, head-lamp glare and full problems also received attention at the technical meetings. The fact that four-wheel brakes can stop a car quickly was not questioned, but one judged from the discussions that many design points must be perfected before the use of this form of braking becomes universal. The danger of losing control of the car when only the front brakes lock seemed to be the chief point of discussion between the advocates of four-wheel brakes and those who are investigating them. That head-lamp lens design is being put on a more scientific basis was shown by the technical session and demonstration devoted to glare and road illumination. The Bureau of Standards' report on fuel volatility research, valuable studies made at Cornell University on the effect of spark advance and the Research Department's progress report on fuel research, filled the Friday session with interesting material.

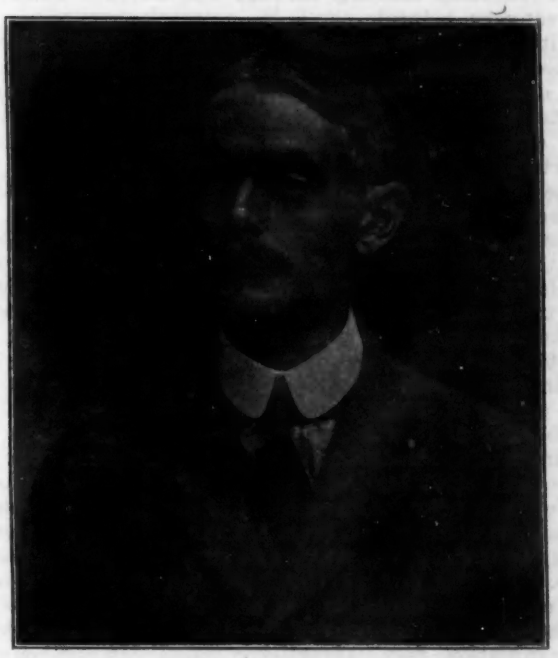
The following pages present a complete report of each of the meetings and all of the sports and entertainment. Nearly all of the papers are printed in full in this issue.

H. M. CRANE PRESIDENTIAL NOMINEE

Nominating Committee Announces Ticket of Society Officers for Year 1924

H. M. Crane was nominated to serve as president of the Society for the next administrative year by the Nominating Committee, which was completed and organized at the Spring Lake meeting. The committee reported the following other consenting nominees for the elective offices next falling vacant under the constitution, that is, after the 1924 Annual Meeting of the Society.

First Vice-President—E. A. Johnston
Second Vice-President, representing motor-car engineering—W. R. Strickland
Second Vice-President, representing tractor engineering—J. F. Max Patitz
Second Vice-President, representing aeronautic engineering—H. L. Pope
Second Vice-President, representing marine engineering—W. C. Ware
Second Vice-President, representing stationary internal-combustion engineering—T. B. Fordham
Councilors (to serve during 1924 and 1925)—J. H. Hunt, A. K. Brumbaugh, M. P. Rumney
Treasurer—C. B. Whittelsey



H. M. CRANE WHO HAS BEEN NOMINATED FOR PRESIDENT OF THE SOCIETY FOR THE YEAR 1924

The members of the 1923 Council who will hold over during 1924 are H. W. Alden as past-president and Councilors W. A. Chryst, F. W. Gurney and A. J. Scaife.

The Nominating Committee was constituted of F. M. Germane, chairman, member-at-large; Ernest Wooler, Cleveland Section; Lester Keilholtz, Dayton Section; George E. Goddard, Detroit Section; O. C. Berry, Indiana Section; C. F. Scott, secretary, Metropolitan Section; T. Milton, Mid-West Section; W. M. Newkirk, Pennsylvania Section; A. W. S. Herrington, Washington Section; E. P. Warner and E. H. Schwarz, members-at-large. A. W. Scarratt, Minneapolis Section, was kept in touch with the committee by telegraph. The members of the committee elected by the Buffalo and New England Sections were not in attendance.

This was the annual Nominating Committee, provided for by the Society's Constitution, under which 20 or more members entitled to vote may constitute themselves a special

Nominating Committee, with the same power as the annual Nominating Committee. The By-Laws of the Society provide that a special Nominating Committee, if organized, shall on or before Nov. 15 present to the Secretary of the Society the names of the candidates nominated by it for the elective offices next falling vacant, together with the written consent of each.

SOCIETY IN A HEALTHY CONDITION

All Reports Show Gains in the Past Year and Indicate Optimism for the Future

In opening the Business Session on Tuesday evening, President Alden expressed appreciation of the work of the members of the Council this year, stating that the average attendance at Council meetings had been good. He spoke briefly with regard to three major subjects to which the Society has devoted special attention this year, namely, highways, transportation and production. He said that the excellent Transportation Meeting held at Cleveland in April showed that the Society is getting in closer touch with the railroads and the electric railways, the railroad people cooperating in a commendable manner and a joint meeting of the Society and the American Electric Railway Association being proposed to be held at Atlantic City in October. President Alden felt that the highway research studies in which the Society is participating are proceeding satisfactorily. He said that the Production Meeting held in Detroit last October had proved very helpful.

With regard to financial matters, President Alden announced that, whereas during the last fiscal year and up to May of this fiscal year the expenses of the Society had been greater than its income, for the period of the current fiscal year ending May 31 a small unexpended income could be reported.

The office staff was commended for effective assistance in the work of the Sections of the Society.

The report of Treasurer Whittelsey reflected the steady growth in the income of the Society throughout the first 8 months of this fiscal year. At the close of business on May 31 last, there was an excess of income over expense of $878.33. At the same time last year there was a deficiency of about $18,300; that is, the net income for the present fiscal year has increased over $19,000 as compared with that for the same period of 1922. In the last score of years, it has been possible except during one year to hold the expense below the limits of the budget and maintain the income at a figure above the budget, leaving a surplus of from $10,000 to $30,000 for each year. Although not an organization maintaining activities for profit, from a financial point of view the Society is operated along the same general lines as a business house. At the present time, the income from members' dues constitutes about 30 per cent of the gross income of the Society, the other part of the gross income being derived from initiation fees, advertising sales, interest on bank balance and investments, miscellaneous sales and contributions from affiliated organizations. The Society is proceeding on the sound policy that its income should be greater than its expense during the years in which business is flourishing, to provide a surplus for periods of depression.

A comparison of the receipt of members' dues shows that about the same number of members had paid their dues on or before May 31 last as had paid them at the same time last year. The total assets of the Society at the end of May amounted to $183,693.75, about $3,500 more than on the corresponding date of 1922. The income during the first 8 months of this fiscal year was $184,687.43, this amount being about $5,600 greater than provided for in the budget.

Lon R. Smith, chairman of the Membership Committee, presented a report on behalf of that committee stating that on June 1, 1923, excluding Enrolled Students, the total number on the rolls of the Society was 5386; the number of Enrolled Students being 244, 87 more than last year. During the year nearly 700 ceased to be members owing to death, resignation or non-payment of dues. Notwithstanding this, the total membership is about the same in number as last year. It is considered that the membership is sounder as a whole from the standpoint of continuing interest in the work of the Society.

In connection with the report of the Meetings Committee, which was presented by Assistant General Manager Hill, President Alden asked for an expression of opinion from the members present as to the desirability of the Society holding a Carnival or a Dinner-Entertainment, similar to those of 1921 and 1922, during Automobile Show Week in New York City next January. A vote was passed indicating that it would be agreeable if the Council decided not to revive this event which was discontinued in connection with the 1923 Annual Meeting in New York City.

Harold W. Slauson, chairman, presented the report of the Sections Committee. He cited the following as among the most important actions of the Sections Committee and the Council this year:

(1) Continuation of the procedure whereby only members of the Society in good standing are eligible for membership in Sections
(2) The defining of territorial limits of the natural field of activity of each Section, these being the basis of appropriations to the Sections from the treasury of the Society
(3) The decision that the Society shall pay to each Section $3 for each Section member who resides outside the territory of the respective Section and not in territory allotted by the Council to any other Section. This is in addition to the Society payment to each Section of $2 for each Section member and $1 for each Society member residing in the respective Section territory although he is not a member of the Section
(4) Official announcement that the principal activities of the Sections being of a professional nature, the expenditure for social activities of Section funds derived from the treasury of the Society should be discouraged. This does not mean that the Sections Committee and the Council do not favor Section outings or entertainments, the expense of which is defrayed through some form of assessment paid by Section members as well as by guests.
(5) The establishment of standard requirements for the formation of a Section

Chairman Slauson announced that the Sections Bulletin issued from the office of the Society had greatly assisted the Sections Committee and the Sections officers, and in addition that the Sections manual is being revised with a view to condensing and making it more effective.

Mr. Slauson presented the following table of percentage of Society members in each Section territory who have become members of the respective Sections:

Section	*Per Cent*
Indiana	52
Buffalo	52
Detroit	50
Dayton	42
Minneapolis	41
Pennsylvania	38
Metropolitan	28
Mid-West	28
New England	24
Cleveland	21
Washington	21

Except in the case of the Buffalo, the Indiana and the Pennsylvania Sections, the figures above given have been computed from Sections reports made as of April 21, 1923. It is expected that the spirit of competition among the Sections will be increased not only in the matter of percentage of membership but also percentage of membership attendance at Section meetings. President Alden said that the Sections Committee had worked hard and done good work, the Sections now being in a better condition than before. He pointed

out that the Committee and office of the Society cannot alone do all that should be done in furthering the growth and value of the Sections and urged the members to support their Sections. He reiterated the statement that the life of the Society depends upon the sections.

Vice-Chairman Charles M. Manly, of the Standards Committee, reported upon the action of that Committee at its session held the same day. His report was approved. Mr. Manly protested against the making of unduly late criticisms of the reports of Divisions of the Standards Committee, stating that the lodging of various objections at the Standards Committee meeting after there had been an opportunity for months to express dissenting views amounted in his opinion to destructive criticism. He said that in view of the fact that the Divisions spend a large amount of time and thought in preparing their reports more consideration should be given them in connection with the tendency to refer back their reports in an offhand manner. He entered a plea for as much constructive criticism as possible in advance of the Standards Committee meetings.

STANDARDS COMMITTEE MEETING

The meeting of the Standards Committee at Spring Lake, N. J., on June 19 was convened by Past-President B. B. Bachman, and later presided over by Vice-Chairman Charles M. Manly. Committee and Society members and their guests to the number of 114 attended, which was very creditable considering the many attractive features of the resort that tended to draw the members from the meeting.

Of 28 reports submitted by 13 Divisions, 27 were approved in original and amended form, only one being referred back as a whole. This was the report on Engine Testing Forms, submitted by the Engine Division, which it was thought should be reconsidered in connection with several suggestions made during discussion. That part of the Nomenclature Division's report on Radiator Nomenclature which defined the several types of radiator core was referred back to the Division largely because of Herbert Chase's discussion. The Electrical Equiment Division's report on Magnet Wire, and the Parts and Fittings Division's report on Fuel and Lubrication Pipe-Fittings were withdrawn prior to the meeting.

The complete report of the action taken on all the reports, together with the pertinent discussion thereon and the names of those in attendance will be found beginning on page 79 of this issue of the JOURNAL.

A number of subjects were suggested for consideration by several Divisions, and these will be included in the schedules of work for the fall. It is not probable, however, that any meetings of Divisions will be called until the latter part of September, when official notice will be sent to all members of Divisions and Subdivisions as in the past.

JUNE COUNCIL MEETING

The meeting of the Council held on June 18 at Spring Lake, N. J., in connection with the Semi-Annual Meeting of the Society, was attended by President Alden, Past-President Bachman, First Vice-President Crane, Second Vice-Presidents Masury and Warner, and Councilors Chryst, Gurney, Scaife, Scott, Smith and Swetland.

The report of the Meetings Committee with regard to the Production Meeting to be held in Cleveland in October and the 1924 Annual Meeting of the Society to be held in Detroit next January was discussed. It was decided not to hold the 1924 Service Meeting of the Society in Chicago during the week of the Automobile Show.

Eighty-nine applications for individual membership were approved. The following transfers in grade of membership were made: Junior to Member, Claude S. Mobley, Arthur H. Rapp, Raymond W. Dwyer, E. Tasso Morgan, Herbert Joseph Howerth; Associate to Member, Howard L. Davis, Charles W. Wolfe, Herbert Scheel, W. H. Marty, N. R. Haas, N. J. Clausen, E. R. Jacobi, O. D. Heavenrich, Victor Jantsch, B. M. Leece, C. H. Paulsen; Junior to Associate, Raymond F. Buckley.

THE COUNCIL MEMBERS WHO ATTENDED THE MEETING

It was reported that up to June 15, 1923, 464 applications for membership and student enrollment had been received during 1923.

The following appointments to the Standards Committee were made:

Iron and Steel Division—J. D. Cutter.
Lubricants Division—H. J. Saladin.

The regulations governing the procedure of the Standards Committee were revised to provide that the letter ballot of Society members on adoption of standards shall be returnable 21 days following the publication in the JOURNAL of the action taken by the Standards Committee on Division reports. It is expected that this will save approximately 30 days' time in the issuance of new data sheets to the members of the Society. The present regulations provide for the counting of letter ballots 60 days following the Society's Business Meeting at which Standards Committee action is passed.

Rule 1 was amended to authorize the closing of the office of the Society at noon on business Saturdays during July and August.

The next meeting of the Council is scheduled to be held in September.

MEMBERS DISCUSS HIGHWAYS

Highways Committee Chairman Bachman Stages Discussion of Relation of Vehicle to Road

The meeting called by Chairman Bachman for Wednesday afternoon, June 20, at Spring Lake, N. J., was well attended. Some time ago Dr. T. J. MacDonald, chief of the Bureau of Public Roads, asked representatives of the automotive and rubber industries to attend a conference in the City of Washington to consider a program of highway research laid out by that Bureau. Much interest was shown in this program by a large number of members to whom copies were sent after the Washington conference. The object of the conference at Spring Lake was to afford an opportunity for a further discussion of those parts of the Bureau of Public Roads program that most concern the automotive engineer, and to formulate a definite policy regarding the relation of the Society to the Government's research program.

NATURE AND OBJECT OF THE TESTS EXPLAINED

A. T. Goldbeck, of the Bureau of Public Roads, explained that his organization is undertaking a series of tests "for the correlation of the motor vehicle and the road to promote the maximum economy in highway transportation." These tests involve the building of a stretch of road made up of slabs of different thicknesses of concrete laid on at least two types of subgrade. Vehicles of different weights will be run over this road and the stresses in the concrete will be measured

for different speeds and loads and for different degrees of surface irregularity by special measuring instruments embedded in the concrete. Measurements of the vertical accelerations of the wheels also will be made by accelerometers mounted on the vehicle. Various other measurements will be made, such as those of spring deflection and of the motions of the vehicle body.

Measurements of stresses in the concrete will be correlated with tests of concrete slabs under repeated impacts produced by an impact testing machine that has been in operation for some time, as well as with stress measurements on concrete roads that are in actual service.

The prime object of these tests is to determine what is the maximum stress to which different thicknesses of concrete road on different types of subgrade can be subjected, and what classes of vehicle, as regards weight, speed, class of tires and design, can be operated without exceeding this safe limit of stress.

The conference discussed the following features of the program:

(1) Classes of vehicles to be used in the tests
(2) Loads to be applied
(3) Sprung and unsprung weight
(4) Speeds
(5) Effect of wheel spacing
(6) Tires

Society's Engineers Discuss the Program

In answer to a question by M. C. Horine of the International Motor Co. as to why the tests were confined to concrete roads, Mr. Goldbeck explained that concrete being a rigid material, it is possible to make stress measurements that would be impossible in other road materials. However, by measuring the stresses produced in concrete slabs by a given class of vehicles and determining the destructive effects of these same vehicles on other types of road it is hoped to secure some reliable information on the loads that the latter type of road will sustain. It would be impossible to make tests on all the many classes of road, hence only a few typical constructions can be given special study.

Information gained through this research is needed by the highway engineers to permit the designing of roads to suit the existing traffic and types of vehicle, and by the automotive engineer and the tire designer to assist in designing vehicles and equipment that shall not impose excessive loads on the highways; both with a view to securing greater economy in highway transport. Mr. Goldbeck referred, in passing, to the research work which is being carried out under Professor Agg's direction at Iowa State College to determine the operating cost factors, fuel and tires as affected by highway conditions. Mr. Horine expressed a hearty endorsement of the Bureau of Public Roads' program as laid out and in doing so expressed the obvious sentiments of the entire conference.

In discussing the details of the program Mr. Horine recommended the inclusion of heavier trucks than originally planned, and it was agreed that the heaviest types of stock commercial vehicle would be included in a chassis weight of 13,000 lb., and that the tests should include this weight. He recommended also that especial attention be given to the effects produced on the road by empty vehicles traveling at high speeds, as this is a condition that imposes maximum destructive effects on the vehicle and probably on the road as well.

Mr. Slauson objected to the projected classification of solid and cushion tires together as one group, pneumatic tires forming another group. P. W. Litchfield explained that there are two types of cushioning, one that depends upon compressed air and the other upon the displacement of vulcanized rubber. Continuing the discussion of the effects upon the road of different types of cushioning, Dr. H. C. Dickinson suggested that for a given dead-load these variations depend entirely upon impact effects that can be determined by the roughness of the road surface. He felt that a study of the methods of securing and maintaining minimum roughness of road surface should accompany a study of impact effects on the road. President Alden stressed the point that the highway engineer's problem in designing a smooth road is parallel to the automotive engineer's problem in designing a vehicle so that it may have a minimum destructive effect and expressed the opinion that the road designer has caused as much damage to trucks as the truck designer has to roads.

The test road that was specially constructed for the purposes of this work is already complete and the Bureau plans to begin tests in about a month, according to Mr. Goldbeck, who appealed to the automotive engineers and to the representatives of the National Automobile Chamber of Commerce for cooperation. He wished the Society to appoint an observer to follow the tests and requested that the National Automobile Chamber of Commerce supply test vehicles, including a 7½-ton truck and one or more semi-trailers. Alfred Reeves, speaking on behalf of the latter organization, agreed to supply these vehicles and the Tire and Rim Association, through Mr. Litchfield, expressed its readiness to supply a man to assist in changing and taking care of tires.

Publication of Results Will be Handled Cooperatively

In discussing the procedure to be followed in publishing the results of the highway tests, H. M. Crane suggested that the cooperative plan by which the joint fuel research was handled by the National Automobile Chamber of Commerce, the American Petroleum Institute and the Society through a steering committee composed of representatives of all three organizations supplied an excellent precedent and should be followed in this case. The suggestion was adopted and the meeting closed with the appointment of Dr. Dickinson and Mr. Goldbeck as a committee to settle the matter of a whole or part-time representative of the automotive industry to supervise the tests.

LARGE-SECTION AIR-CUSHION TIRES

Problems Involved in Shoeing a Car with Low-Pressure Air

Despite the fact that the session held on the evening of June 20, 1923, had to do with the subject of low pressure, it was decidedly a high-pressure meeting that attracted members and guests enough to more than fill the grand ballroom of the spacious Essex and Sussex Hotel, and late comers had perforce to be satisfied with being spilled over to the adjoining verandas to peer through the doorways and French windows and hear the speakers as best they might. As a guarantee of smooth operation on low-pressure atmospheric conditions at high-pressure and great speed, Thomas J. Lítle, Jr., was chairman and, following his opening remarks, he introduced the speaker of the evening, James E. Hale, of the Firestone Tire & Rubber Co., who presented his paper entitled "Shoeing a Car with Low-Pressure Air." The paper is printed in full in this issue of The Journal, but an outline is included herewith to further a better understanding of the prominent points developed by the discussion that followed its delivery.

Mr. Hale described the results of a deliberate attempt to make motor vehicles ride on air that is at a low pressure, through the use of an air-cushion tire having greater carcass flexibility than is usual and by enlarging the size of the tire section so as to provide a greater area of contact between the tire and the pavement. The goal tried for was to increase the area of contact sufficiently so that air pressures ranging from 20 to 35 lb. per sq. in. could be employed in actual practice.

The author first mentioned the fundamental conditions and this consideration was followed by statements as to what advantages the air-cushion tires containing air at low pressure give to a car. The effects on car operation were presented at some length, inclusive of considerations regarding car speed, steering ability, front-wheel shimmy, traction, braking control, blow-outs, punctures, side-sway and other factors of influence.

Durability and tire cost were treated in some detail, specific applications of air-cushion tires to automobiles were considered and a discussion of their desirability was invited. In conclusion, recommendations were made for a new tire-size nomenclature, in regard to oversizing and to tire-deflection limitation; and specific tire-size recommendations for air-cushion tires on stated makes of car were advocated.

Bumping the Bumps

In addition to the numerous lantern-slide illustrations, ultra-rapid motion-pictures were shown that slowed down the movements of two cars filled with passengers, one car being equipped with high-pressure pneumatic tires and the other with low-pressure air-cushion tires, so that comparisons as to their smooth-riding qualities over bad pavements were plainly, and, as shown by the jouncing of the passengers, sometimes laughably evident. The greater smoothness of car travel shown by the machine equipped with air-cushion tires, when operating over seriously bad pavement, was thus demonstrated.

System Applied to Discussion

The advantages of creating discussion by distributing cards throughout the audience upon which members write their questions and sign their names, as was done at a recent meeting in Detroit, were again demonstrated. The cards, after being collected, are presented to the chairman, who reads the questions in turn and requests an immediate answer from the author. In this manner a far greater number of questions can be asked and answered, the questions are stated more clearly and the subject is thereby given a discussion that is much more thorough and general. Chairman Lítle stated his hope that this system of discussion will be adopted generally by the Sections of the Society when holding future meetings.

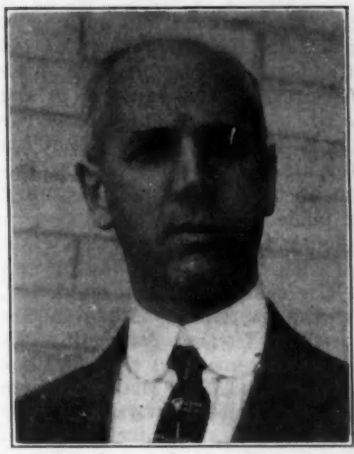
The Questions and Answers

An outline of the queries of major importance is stated now by giving, in general terms, Mr. Hale's answers, the character of the query being implied rather than quoted verbatim. Mr. Hale said that the side walls of the 7.30-in. tire would not roll over onto the road when under a heavy car if the air inflation-pressure is high enough, and that the air-cushion tire resists "curb scraping" of its side walls better than the high-pressure pneumatic tire does. The suggestion of using the term "super-pneumatic" in place of "air-cushion" as a descriptive term it was thought by Mr. Hale should be referred to the Nomenclature Division of the Standards Committee. The running temperature of the air-cushion tire was said to be low, and that they hold their pressure better than high-pressure pneumatic tires do. He thought the provision of grooved treads for the air-cushion tire looks promising, but said that nothing had yet been done regarding the matter and that no tests of their application to passenger buses had been made. He said also that the comparative tests made of the air-cushion tires on taxicabs, referred to in the paper, were under identical weather conditions in April, 1923, while the taxicabs were running side by side. The query regarding vulnerability to punctures of the air-cushion tire was referred to the statements made in the paper, and it was said regarding how many air-cushion tires had been run to destruction that this information would be made available later.

The use of snubbers was said to be necessary when using air-cushion tires because of the excessive rebound they give to the springs, and the effect of deep ruts on the side walls was stated to be practically the same as for high-pressure pneumatic tires. The dust and stone-throwing ability of the air-cushion tires was acknowledged. An answer to the question as to the relative volume and weight of air in the air-cushion and in the high-pressure pneumatic tires was deferred.

Opinions From Others Who Were Present

Since so much time had been gained through using the question cards, time was yet available for further expressions of opinion, and Chairman Lítle therefore called upon representative members of the audience, by name, for critical comment. The representative of the Ross Gear & Tool Co., Lafayette, Ind., Mr. Chandler, referred to the engineering study of the subject his company has been making and said it had succeeded in producing a gear for use with air-cushion tire-equipment that is satisfactory. He considers the use of these tires as being involved with factors relating to steering, drag linkage, springs and the like.



J. E. Hale

T. J. Lítle, Jr.

Charles L. Nedoma, of the Cadillac Motor Car Co., Detroit, said that he had found the steering to be more difficult and that the liability to punctures of air-cushion tires was greater, citing his knowledge of an instance of six punctures of such a tire within 8500 miles of travel. Ernest Wooler, of the Cleveland Automobile Co., emphasized what Mr. Hale had said regarding skidding; he drove to the meeting in a car equipped with air-cushion tires and reported having made faster average time than did his companions who drove cars having ordinary pneumatic tires.

The statement was made by P. W. Litchfield, of the Goodyear Tire & Rubber Co., Akron, Ohio, that tire makers had been trying for a long time to persuade automobile builders to use tires of larger cross-section and lower air-pressure. It is a very delicate question, in his opinion, as to how far to go in this direction. He believes that tire rims should be made wider than recommended by Mr. Hale, and spoke of increased "shimmy" and steering difficulties when tire rims are too narrow. He mentioned a 5-in. rim for a 6-in. tire as constituting good super-pneumatic tire equipment, with an inflation pressure of about 26 lb. per sq. in. He cautioned tire makers that they must not get tire walls too thin, and said that great attention must be paid to attaining lateral stability.

Mr. Litchfield believes that there always will be times when conditions will demand "oversizing"; that is, a larger size of tire than is normal for a given equipment. Also, because of variations in wheel diameters and the like, tire sizes should be specified only in nominal terms such as 5-in., 6-in. and the like.

The representative of the United States Rubber Co., Hartford, Conn., S. P. Thacher, agreed mainly with Mr. Hale's statements but took exception to those referring to punctures and to power consumption. He favored a middle course with regard to cross-section and air pressures and said that, with "balloon" or air-cushion tires, the effect on the steering ability is bad because the wheel itself turns before the tire turns with it; that is, the wheel turns to the right or left, inside the tire, before the tire can follow it. He fears that the tire carcass may be made too thin, and said that he would be afraid to ride at 60 m.p.h. on tires having thin walls.

W. H. Allen, of the B. F. Goodrich Co., Akron, Ohio, believes the tire itself to be but a small portion of the problem and thinks that the other engineering factors involved constitute the greater difficulties. C. L. Moody, of the Fisk Rub-

ber Co., Chicopee Falls, Mass., stated that he had nothing to add to what already had been said. H. W. Slauson, of the Kelly-Springfield Tire Co., Cleveland, made brief remarks on the subject of air inflation-pressures in relation to the amount of load carried by the tires. A representative of the Miller Rubber Co., Akron, Ohio, C. F. Ofensend, said that his company favors a tire base for air-cushion tires of approximately the same width of rim as is now used for ordinary pneumatic tires, after having made tests.

In his closing remarks, following the discussion, Mr. Hale said that differences of opinion with regard to all the factors pertaining to the air-cushion tire were to be expected, but that he was content to allow the statements made in his paper to stand as they are, without further comment. He mentioned the extremely rapid advancement in tire development that had occurred recently, and believed that whatever details may be right for tire construction will come into being eventually.

A more than usual spirit of interest pervaded this evening session and, in the words of a prominent member who is best qualified to know, "It went over, *big!*"

ANNUAL FIELD DAY AN ACTIVE SPECTACLE

Races, Jumping, Throwing and Other Events Test Skill of Members at Spring Lake

The Annual Society Field Day at Spring Lake brought out many familiar faces and some few new ones. Engineer athletes matched their skill in jumps, sprints and general muscular activity with hopes of collecting a share of the handsome prizes. The carrys-on were staged on the spacious lawn running along the seashore and the Atlantic formed a picturesque background. The entry list was slightly affected by the unusual activity of Old Sol's hot-spots, he being engaged in the business of creating new temperature records for himself in the environs of Spring Lake. Fortunately, cool breezes wafted in off the ocean and gave courage to enough competitors to make everybody hustle.

The Porter sisters featured the baseball throwing contest as predicted by the fans. Our diminutive friend Buckwalter was in evidence in all events where avoirdupois is an asset. Mrs. Ernest Dickey came all the way from Dayton with her hiking togs to show the ladies the way in the races set apart for the fair sex. The summary of results follows:

50-Yd. Dash (Men Under 30)—First, E. O. Jones; second, M. P. Whitney; third E. Y. Davidson, Jr.

50-Yd. Dash (Men 30 to 40)—First, Neil McMillan, Jr.; second, B. W. Brodt; third, J. C. Talcott

50-Yd. Dash (Men Over 40)—First, Rollin Abell; second, T. V. Buckwalter; third, George Briggs

50-Yd. Dash (Boys Under 12)—First, Robert Germane; second, Dan Foster; third, L. Schwitzer

50-Yd. Dash (Women)—First, Mrs. Ernest Dickey; second Mrs. C. H. Beegle; third, Mrs. C. F. Scott

Fat Men's Race—First, T. V. Buckwalter; second, A. K. Brumbaugh; third, H. F. Peavy

Shot Put—First, T. V. Buckwalter; second, E. Y. Davidson, Jr.; third, Rollin Abell

Hop, Skip and Jump—First, B. W. Brodt; second, F. G. Whittington; third, M. P. Whitney

Three-Legged Race—First, Neil McMillan, Jr., and E. O. Jones; second, B. T. Lemon and J. J. Cucurello; third, George Briggs and A. W. S. Herrington

Potato Race (Men)—First, Neil McMillan, Jr.; second, B. T. Lemon; third, M. L. Hull

Potato Race (Women)—First, Mrs. Ernest Dickey; second, Mrs. Albert G. Metz; third, Mrs. Chase W. Wolfe

Standing Broad Jump (Men Under 40)—First, R. M. Powell; second, F. F. Kishline; third, W. S. James

Standing Broad Jump (Men Over 40)—First, T. V. Buckwalter; second, E. E. Wemp; third, Rollin Abell

High Jump—First, J. C. Talcott; second, B. W. Brodt; third, A. M. Yocom

Throwing the Baseball (Women)—First, Norma Porter; second, Ruth Porter; third, Mrs. C. H. Beegle

Egg Race (Women)—First, Mrs. G. A. Kraus; second, Mrs. Ernest Dickey; third, Mrs. C. F. Scott

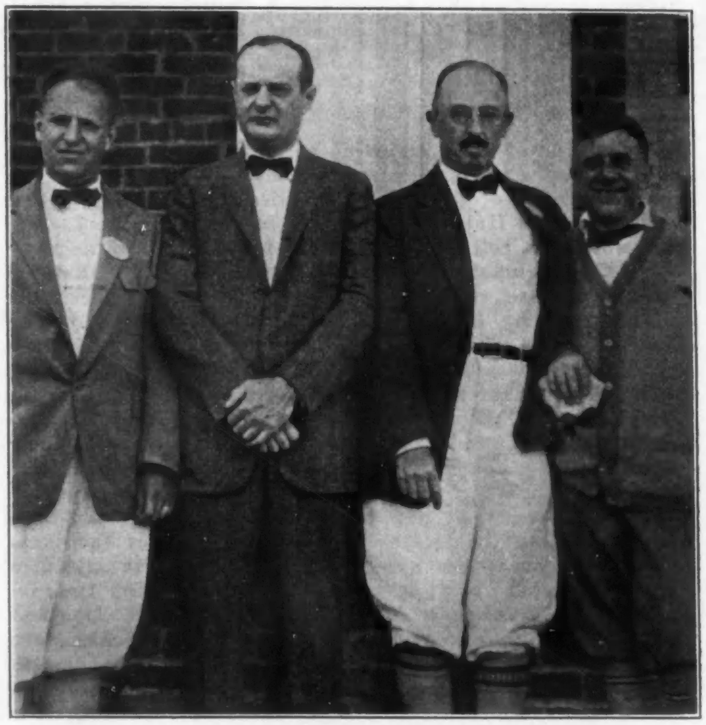
Inter-Section Relay Race—First, Detroit; second, Metropolitan

It so happens that the lawn at Spring Lake is kept in greenish hue by a system of concealed sprinklers. After the field contests had been completed, the contestants were invited into the area of activity of these very efficient irrigators for the supposed purpose of receiving instructions from the officials. When all were watching the field director attentively, the pent-up activity of the sprinkling system was released with results that satisfied the humorous qualities of the gallery but that had a dampening effect on the spirits of the competing athletes. Thus ended the 1923 Field Day.

SECTIONS ROUND TABLE AT SPRING LAKE

Attendance, Collection of Dues and Local Membership Most Discussed Topics

Representatives from nine of the eleven Sections met with the Sections Committee and members of the staff interested in Sections administration for the Sections Luncheon at Spring Lake. President Alden assured the Sections representatives that the Council stands squarely behind any constructive work of the Sections, since the life of the Society is measured by their activities. Assistant General Manager Hill reminded the Sections officers that they are in the show business and that, like other showmen, they must choose topics interesting to their audiences, book speakers well in advance, advertise at least a week ahead



H. W. Slauson Hugh Corse O. A. Parker George T. Briggs
SOME OF THE SECTIONS COMMITTEE

in notices with a strong sales appeal, stage the meetings effectively, begin on time and end promptly.

Each Section represented contributed its experience for the benefit of the others. Cleveland believes that a Section should serve all Society members in its territory, whether members of the Section or not. The Dayton Section has been able to cooperate satisfactorily with the Dayton Engineering Society at a lower cost than it could work alone. The Indiana Section plans to maintain the interest already roused by securing good speakers in advance. National Society meetings offer excellent opportunities.

To make meetings more useful to those present, the Detroit Section plans to have its committee members seated together and tagged so that inquiries and suggestions will not go astray. Written questions for discussion of papers at meetings, in place of questions from the floor, save time and improve the type of questions asked. This Section went on record as favoring a contributing, purely local membership in the Section for men interested in the meetings, although not eligible for Society and Section membership.

The Metropolitan Section, serving a big membership with diverse interests, approves the suggestion that arrangements be made for "Section associates." The program for the coming year will cover operating problems. This diversity of interests and the wide area served by the Mid-West Section limit attendance at purely technical meetings. It is planned, therefore, to provide a year's program of three general, three technical and three special meetings to be addressed by prominent and popular speakers. Mid-West feels that while a general $5 increase in Society dues would limit Section membership and attendance at meetings, a $3 increase would be beneficial, if Section dues were omitted.

The Minneapolis Section finds that its distance from automotive centers makes securing speakers difficult. Attendance is another serious problem. The Pennsylvania Section also suffers from a diversity of industries in the large area served. Attendance at meetings is the chief difficulty faced, but joint meetings with other organizations have not been a satisfactory solution. Pennsylvania also approves some form of separate local membership in the Sections. The Washington Section, although situated in a difficult territory, believes that with staff assistance, it will be able to succeed.

Discussing the question of Section dues, President Alden emphasized the fact that increased Society dues in place of Section dues would be unfair to the more than 50 per cent of the membership who live outside territory which can be effectively served by the Sections. C. T. Myers suggested that dues be increased only for members living in Section territory as prescribed by the Council. George T. Briggs and Chairman Slauson believe the solution of increased interest in Section membership with consequent increase in dues paid, lies in securing A-1 papers and selling the value of Section membership intensively.

The roll of those present included

Herbert W. Alden	Lester S. Keilholtz
O. C. Berry	William E. Kemp
George T. Briggs	T. J. Litle, Jr.
F. F. Chandler	George L. McCain
Edward L. Clark	H. O. K. Meister
Coker F. Clarkson	Taliaferro Milton
Hugh R. Corse	C. T. Myers
T. F. Cullen	Phil N. Overman
H. E. Figgie	O. A. Parker
A. W. S. Herrington	Harold W. Slauson
C. E. Heywood	C. B. Veal
L. Clayton Hill	C. S. Whitney

Conrad H. Young

MEMBERS ARE KEEN SHARPSHOOTERS

Clay Pigeons Suffer Many Casualties as Shells Burst at Spring Lake Meeting

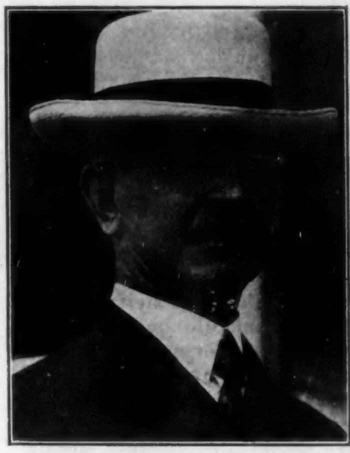
The clear blue sky above the Atlantic's restless surface formed an excellent background for the trapshooters to sight against at the Summer Meeting. The traps were set up on the beach directly in front of the two hotels and each day's shoot was watched by a large gallery of members. Many novices tried their luck with the double barrel and left the meeting as ardent clay bird spotters. A shoot was held each day and the finals were shot on Friday, with handicaps given the lesser lights based on their previous days' scores.

W. H. Miller broke 48 targets on Tuesday and took the prize for that day. R. S. Ellis won the Wednesday shoot with a perfect 50. The Thursday event was taken by H. P. Hobart, his handicap helping him to nose out Ellis. The championship shoot on Friday gave W. H. Miller a deserved medal, for he shot a perfect score of 50 from scratch. Ellis was second with 49 from scratch and Lon Smith took third credit with 47.

STANDARD HEAD-LAMP ILLUMINATION

Automotive and Illuminating Engineers and Legislators Discuss Common Problems

Indications point to a tendency on the part of State legislators to reconcile their laws applying to head-lamp illumination in such a way as to approach a reasonable degree of uniformity. The automotive manufacturer feels that head-lamp legislation is reasonable and just and is prepared to equip his vehicles so as to conform to these laws. In the few years that have elapsed since the Lighting Division of the Society's Standards Committee and the Society of Illuminating Engineers began their study of the head-lamp problem so much progress has been made that the only important task that remains is the education of the car builder and user in the essential facts brought out by the study of the problem. Representatives of the automotive industry, the State Legislature of New Jersey and the illuminating engineers all gave their views on lighting problems at the Head-Lamp Session on Thursday evening, June 21, at Spring Lake. The session was followed by a demonstration of head-lamp illumination, accompanying a short paper, staged by members of the Nela Park Research Laboratories' staff of the General Electric Co. This demonstration illustrated methods of measuring glare and of determining lens effectiveness.



Dr. C. H. Sharp

R. N. Falge

Illuminating Engineers Give Interesting Papers

B. B. Bachman, who presided at the meeting, introduced R. N. Falge of Nela Park who read his paper entitled Importance of Better Automobile Head-Lamps and Proper Adjustment, which will be found elsewhere in this issue. Dr. C. H. Sharp made an address in which he gave a short historical review of the progress made in head-lamp standardization. Within the past year testing specifications for the approval of road lighting devices were formulated by the Lighting Division of the Society's Standards Committee in cooperation with the Society of Illuminating Engineers and had been submitted to State officials for their guidance. These specifications were approved by several States which agreed recently to approve only such devices as conformed to these specifications.

The testing specifications, as outlined at first, were very

lenient but as time went on they were made more strict. Devices that formerly received the approval of the State authorities without much difficulty were subsequently weeded out. Dr. Sharp illustrated by a comparative table the differences between the head-lamp testing requirements of various States in 1916 and in 1923. In emphasizing the point that the elimination process did not imply a mortality of good things he stated that many devices which were approved in 1916 were actually so impractical that no attempt was ever made to manufacture them.

In conclusion Dr. Sharp stated that the preliminary work of the Lighting Division of the Society's Standards Committee and the Society of Illuminating Engineers was practically complete and their work should now be taken up by the membership of the Society. He anticipated the early adoption of the recommended specifications for testing headlamps by the State Legislatures and the only remaining problem was, therefore, the education of the car builder and user.

The Legislator's Point of View and the Manufacturer's Problem

The Motor Vehicle Commissioner of the State of New Jersey was represented by James J. Shanley, who described the pioneer work done by his State in eliminating the glare danger. New Jersey took action in 1922 to adopt the recommendations laid down by the two cooperating organizations and found them most effective. In expressing the Society's appreciation for the cooperation they had received from the New Jersey legislative authorities in the difficult task of handling the road-lighting problem, Mr. Bachman called upon Alfred Reeves, general manager of the National Automobile Chamber of Commerce, to act as spokesman for the automobile companies.

Mr. Reeves felt that the automotive manufacturer was well satisfied with the State legislation regarding head-lamps and was anxious to cooperate to the best of his ability by equipping his vehicles in such a way as to conform to the requirements. It would be of great assistance, however, if he could be given time to adjust himself and his product to the rapid changes in legislative requirements. The fact that State Legislatures now differed so widely in their requirements did not tend to make the automobile builder's task any easier, but the tendency toward uniform requirements that Dr. Sharp predicted was a very hopeful sign. He would suggest that the States prepare a formula and allow the manufacturer to make his product in such a way as to conform to this requirement. He would also suggest supplementing this requirement of a formula by providing for some form of inspection in every State.

In the discussion that followed, A. D. T. Libby asked for information as to the most effective lens or lighting device on the market at the present time. The question was answered by E. C. Crittenden, of the Bureau of Standards, who was of the opinion that it is impossible to characterize any device as the best, since the merit of any such device depends upon the driving speed and the personal taste of the operator. Many inquiries had been received at the Bureau from people who desired a formula such as Mr. Reeves had suggested. He was strongly in favor of legislation of this kind provided the States demanded uniform requirements and administered the laws reasonably.

Importance of Adjusting Head-Lamp Devices

Mr. Crittenden brought out the point that a device which has been approved by State authorities may be almost useless if it is not properly adjusted. A recent test of ordinary passenger vehicles in regular use in the City of Washington, which was made by the Bureau of Standards' staff, had revealed the fact that of 400 cars tested, 5 to 6 per cent had properly adjusted head-lamps, 34 per cent were fair and 60 per cent glared. These same figures applied equally to new cars. The garageman is indifferent to the necessity for head-lamp adjustment; perhaps because there is no money in it. If the garageman's goodwill could be gained by making it worth his while, one important phase of the required educational work would be accomplished.

The present practice of dimming head-lamps when passing or meeting another vehicle on a badly illuminated road was referred to by H. M. Crane who asked Doctor Sharp and Mr. Shanley for an opinion regarding the use of properly adjusted head-lamps on such roads. He felt with many other engineers that the dimming practice left the driver too unprotected and asked for information on the legislative attitude on this point. Mr. Shanley said in reply that there was no obligation on the part of the driver to dim his head-lamps anywhere in New Jersey and that there should be no necessity for dimming provided a proper device were used. Following out this idea, Prof. R. C. Gowdy, of the University of Cincinnati, gave a review of the road and laboratory tests made by him recently which brought out the importance of ditch illumination and the necessity for smoothness of lighting. He considered the problem of head-lamp illumination a very important refinement and one that closely concerned the automotive engineer. Much difficulty had been experienced with aiming and focusing light but it was felt that this no longer presented any serious difficulties. The session was followed by a most interesting verbal and optical demonstration of head-lamp devices and their operation by R. N. Falge and W. C. Brown.

HORSESHOE FLINGERS HAVE INNINGS

The presence of horseshoes at a meeting of automotive engineers does not seem to be fitting. However, due largely to the enthusiasm of A. D. T. Libby, this equipment was gathered together for a large group of slingers who tried to outdo one another as peg-ringers. A surprising amount of interest was shown in this time-worn pastime and one had to be clever to finish among the winners. H. N. Parsons proved to have the best eye. W. L. McGrath was second, and Booster Libby, who staged and ran the fracas, had to be contented with third.

FOUR-WHEEL BRAKES

For Usage by the General Public, Are They to Be or Not to Be?

The morning session held June 21 at Spring Lake, N. J., was devoted to lengthy consideration of the problems involved when brakes are applied to all four wheels of a car. President H. W. Alden was chairman, and a very representative audience of several hundred members and guests was assembled. In his introductory remarks, Chairman Alden said that the devotion of this session to the subject of four-wheel brakes had been decided upon only after due deliberation, and that the opening-up of this subject at this time had been voted opportune, although some comment had been made to the effect that it was premature.

The first paper presented was by Alvin M. Yocom, chief engineer of the U. S. Axl eCo., Pottstown, Pa., its title being Mechanical Braking on Four Wheels as a Present Automotive Necessity. The author stated that, when used in conjunction with the braking effect of the engine, two-wheel brakes work well in retarding a car on long or heavy grades but that, for emergency stops, by far the most frequent, two-wheel brakes do not give a driver the positive control of the vehicle and the sense of security that are imparted by the retarding effect of braking on four wheels.

The mechanical four-wheel braking system manufactured by the company the author represents was described and illustrated by lantern slides, the claim being made that the front-wheel portion of the system can be connected and equalized with any of the present-day rear-axle or transmission brakes without discarding any of the rear-axle or transmission brake-material. The equalization of brakes was discussed in some detail by the author, inclusive of foreign practice, and other features such as "fight" in the

brake-pedal, the mounting of the steering-arms and the distribution of brake-shoe pressure to prevent chattering and "grabbing" were treated at some length.

The paper by Marcel Guillelmon, vice-president of the Renault selling branch, New York City, was descriptive of the mechanical four-wheel braking-system of the Renault car. The advantages of its servo-brake mechanism in regard to braking power, smoothness of operation and adequate car control were set forth, and the lantern slides illustrating its principles were explained.

The author stated that the high car-speed demanded by present-day drivers of automobiles also demands braking systems that more adequately overcome the effects of such increased momentum than is possible with ordinary brakes applied only to the rear wheels. Since, at the time the brakes are applied, the greater part of the weight of the car is thrown upon the front axle and the front wheels, he believes it imperative that brakes be applied also to the front wheels, and that at car speeds of more than 40 m.p.h. it is unsafe to attempt to stop a car quickly if it is equipped only with ordinary rear-wheel brakes.

Malcolm Loughead Charles L. Sheppy Marcel Guillelmon Alvin M. Yocom

THE AUTHORS OF THE THREE PAPERS PRESENTED AT THE FOUR-WHEEL BRAKE SESSION AND A PROMINENT FIGURE IN THE DISCUSSION

M. Guillelmon said that the editor of *Omnia*, Paris, France, showed very positively in 1921 that front-wheel brakes will prevent skidding, and gave a demonstration of this, using a toy automobile on an inclined plane that represented a steep grade. When the rear wheels of this little car were locked, the car ran down the incline and its rear wheels skidded slowly through a semi-circle until, at the bottom of the incline, they occupied the position that the front wheels had originally. When the front wheels were locked and the rear wheels were free to turn, the car descended the incline slowly without skidding around. The author stated that this demonstration can be made also with a full-size car that is equipped with brakes on all four wheels and that, if the brakes on all of its four wheels are applied simultaneously, the car will stop without any lateral skidding.

It is M. Guillelmon's experience that with the more perfect car control attained by using brakes on all four wheels that are actuated by a servo-brake, it is safer to travel at high speed and, therefore, the average speed of car-travel that can be maintained is very much greater; further, that this braking system is also of great advantage in city travel through congested traffic, which necessitates continual quick stopping. He said that after one has become accustomed to the use of four-wheel brakes on a car, to ride in a car equipped only with ordinary rear-wheel brakes gives one the same feeling of uncertainty and danger that would be felt if one were to ride on a railroad train at express speed and knew that the train was not equipped with airbrakes on all its wheels.

Owing to a most unfortunate delay, Malcolm Loughead, chief engineer of the Four Wheel Hydraulic Brake Corporation, Detroit, was prevented from being present at this session and so did not present his paper descriptive of the four-wheel braking-system actuated by hydraulic pressure that is manufactured by the company he represents. However, the paper was presented at the May 17 meeting of the Detroit Section, and a rather detailed summary of it was printed in the June, 1923, issue of THE JOURNAL on p. 611.

OPINIONS FOR AND AGAINST FOUR-WHEEL BRAKES

Following the call by Chairman Alden for discussion of the subject after the presentation of the papers, Charles L. Sheppy, chief engineer of the Pierce-Arrow Motor Car Co., Buffalo, said that tests and research work over a considerable period of time have shown his company that the application of front-wheel brakes to the average car of today cannot be considered safe. He stated that if the front-wheel brake has to be considered seriously for regular production, the following items should have serious consideration so that the application of front-wheel brakes will provide additional safety to the vehicle and not a menace.

(1) The front axle should be designed to withstand the torque due to front-wheel brakes
(2) Front springs should be of liberal width, should have an extra top leaf under tension, should have a center bolt to dowel into the axle, should be well supplied with rebound clips, should have the smallest possible arch under load and preferably a straight arch under load
(3) Spring bolts, spring clips and shackles should be of liberal size and of first-class material
(4) The cross coupling steering-rod should be straight, if possible, and, where spring-backed ball sockets are used, they should have a very limited amount of travel, preferably none
(5) The steering-pivot axle should have liberal bearing surfaces and be of such design as to withstand the additional stresses imposed by the use of front-wheel brakes. The steering levers should be kept as straight as possible and be of liberal sections and first-class material
(6) Bearings of sufficient capacity should be selected. The additional stresses on the front steering axles require serious consideration as to the loads imposed on front-wheel bearings
(7) The steering-gear operation should not affect the operation of the brakes, and the operation of the brakes should not affect the steering-gear operation in any way

TABLE 1—TESTS OF STOPPING DISTANCES OF THREE DIFFERENT TYPES OF BRAKE APPLICATION

	Type of Brake		
	Rear, External-Band Brakes	Four Brakes, Internal Shoes	Four Brakes, External Bands
Total Weight of Cars, lb.	6,000	6,000	6,000
Total Surface of Brake-Lining, sq. in.	332.4	308.6	600.0
Weight per Square Inch of Lining, lb.	18.1	19.4	10.0
Stopping Distance, in Feet, at			
20 m.p.h.	35	23	15
30 m.p.h.	70	45	35
40 m.p.h.	113	74	60
50 m.p.h.	175	114	90

Comparative Figures Based Upon a Coefficient of Adhesion of 0.9

		Two Brakes	Four Brakes
Wheelbase, in.		138	138
Height of Center of Gravity from Ground, in.		36	36
Total Weight of Car, lb.		6,000	6,000
Weight on Rear Axle, Level Road	per cent	58.6	58.6
	lb.	3,500	3,500
Weight on Front Axle, Level Road	per cent	41.4	41.4
	lb.	2,500	2,500
Transfer of Weight, Wheels Locked by Brakes	per cent	14.0	23.6
	lb.	840	1,410
Transfer of Weight on Grades Expressed in Percentage of Road Length. On a Grade of, per cent,			
10	per cent	15.1	25.1
	lb.	906	1,500
20	per cent	16.6	27.1
	lb.	995	1,625
30	per cent	18.6	29.6
	lb.	1,115	1,775
Greatest Transfer of Weight from Rear to Front	per cent	18.6	29.6
	lb.	1,115	1,775
Weight Remaining on Rear Axle	per cent	40	29
	lb.	2,385	1,740
Maximum Torque Transmitted to Each Pivot Axle, lb.-in.		.....	31,000
Bending Moments, in.-lb.			
Vertical		.....	27,800
Horizontal		.....	25,000
Combined		.....	37,400

(8) Center-point steering is not essential in the application of front-wheel brakes, its only advantage being that there is less load on the cross coupling steering-rod

(9) Consideration should be given in regard to what interpretation the State authorities of the several States will place on four-wheel brakes as coming within the law of the States that require two independent and separate set of brakse

Mr. Sheppy also gave statistics of tests made to determine stopping distances with three different types of brake; rear external band, four brakes having internal shoes and four brakes having external bands, which are given in Table 1.

These comparative figures show that for two and for four-wheel brakes, respectively, the car of today having only two brakes at the rear and a front axle and springs designed only to take care of static loads is not adapted to withstand the additional weight and torque imposed by the use of front-wheel brakes. Other factors mentioned by Mr. Sheppy included the influence of front-wheel brakes on spring design and manufacture, the use of less powerful brakes on the front wheels, and whether to use external bands, internal bands or internal expanding shoes. He stated that internal brakeshoes should be made, preferably, of aluminum, to help cancel the expansion of the drum as it becomes heated. With due consideration for a liberal factor of safety and when properly designed, four-wheel brakes are a desirable addition but, otherwise, they had best be left off.

Full Consideration of All Phases Must Precede Production

H. M. Crane, consulting engineer, New York City, reiterated the fact that very serious problems are involved with the application of four-wheel brakes to general usage by the public, and voiced his belief that the industry should not allow itself to be rushed into four-wheel-brake production. He thinks that the industry should allow itself ample time to work out all the problems and thus make sure that when cars having four-wheel brakes are put on the market they will be as nearly perfect as engineering skill will permit. His reasons for advocating caution were stated in too great detail for reproduction here, but it is expected that they will be printed verbatim in a later issue of The Journal. He also rehearsed the possibilities of the transmission brake, and made pertinent comment on other important factors relating to the general subject of braking.

Chairman Alden said that the company he represents, the Timken-Detroit Axle Co., Detroit, is working on the four-wheel brake problem. C. T. Myers, consulting engineer, Rahway, N. J., stated his agreement, in general, with what Mr. Crane had said. W. G. Wall said that the die is already cast, since several makes of car now have four-wheel brakes. He favored these brakes but mentioned the difficulties of equalization and adjustment. He suggested the possibility that some other, such as a tubular, section may become necessary in place of the usual I-beam section for front axles, and was in general agreement with what had been said regarding difficulties of application. Joseph A. Anglada was in general agreement with what Mr. Wall had said. David Beecroft believes the subject affords the industry an opportunity, in that the automotive engineer should say whether four-wheel brakes are suitable for public usage, without domination or influence by sales considerations. M. Guillelmon, replying to a question, estimated that 75 per cent of European cars of 10 hp. and over have four-wheel brakes, because car speeds there are so great.

T. J. Litle, Jr., thinks that four-wheel brakes must come into being because most accidents result from poor brakes. He does not agree that they must have servo-mechanism, favors such brakes when equipped with external bands and believes four-wheel-brake difficulties are mainly those of proper equalization. L. H. Pomeroy discussed the theoretical differences between external and internal brakes; he mentioned the varying coefficients of friction that cause variations in the power of the wrapping type of brake and spoke of the necessity of having very rigid brake-drums and shoes for external brakes. He thinks the four-wheel brake will come into being in the United States and that automotive engineers should believe in it and develop it. P. W. Litchfield and C. M. Manly were also contributors of discussion pertaining to engineering aspects of the subject.

Following this session, demonstrations of cars equipped with four-wheel brakes of the types under discussion were made on the parkway in front of the Essex and Sussex Hotel; members and guests were thus given opportunity to ride in these cars and make comparisons of their braking ability.

METROPOLITAN IS CHAMPION SECTION

Takes Inter-Section Trophy for the Second Consecutive Year at Summer Meeting

Each of the members or teams winning a place in the sports events at Spring Lake collected a specified number of points which were credited to the Section he or she represented. The Section scoring the greatest point total was declared the champion for 1923. The scheme operates much the same as that used at intercollegiate track and field meets. It was started last year at White Sulphur Springs and promotes good-natured rivalry between the Sections of the Society.

When all the athletic battles had died away, it was found that Metropolitan Section had repeated its successful effort of 1922 and had won the cup for the second time. This was due largely to the New York monopoly on the tennis and swimming places, although some points were picked up in the other sports. The Detroit Section finished second and Cleveland was third.

The prize for ability as an all-round athlete went to Gor-

don Brown for the second time. His prowess as a water nymph carried him to the peak just ahead of N. G. Shidle, the tennis champion, and I. W. Danforth, the golfer.

FUEL-SESSION PAPERS AROUSE INTEREST

Lower Mileage in Winter with Heavy Fuels and Effect of Spark Advance Discussed

H. M. Crane, chairman of the Research Committee, opened the Session with a brief statement regarding the fuel-research program of the Society and introduced S. M. Lee, who presented the report of work accomplished at the Bureau of Standards since the Annual Meeting. This report, which is published elsewhere in this issue, includes a description of a series of road tests similar to those reported last winter, but less comprehensive in their scope and run under cold-weather conditions that confirmed the results obtained in warm weather. The author also gave a detailed account of the methods used and of the results obtained in the altitude chamber where conditions of air and jacket-water temperature are controlled and accurate records of performance can be kept. The results included a study of the specific consumptions of the test fuels under all conditions of steady running as regards load and speed, measurements of relative crankcase dilution with the different fuels and a brief statement of results obtained under conditions of acceleration. A further study of the latter and of the startling characteristics of the fuels is to follow.

The chairman, in commenting on the paper, explained that after the beginning of this research project about a year ago it was found necessary to educate the Steering Committee to the necessity of giving the men handling the details of the problem a free hand to follow out the lines of work that offered the most promise rather than to lay down a rigid program for the investigation. In the beginning the Bureau of Standards had been hampered by the rigidity of the program first specified, but for the last few months it had been given a free hand to investigate the particular conditions of operation that most emphasize the differences in performance chargeable to variations in the fuel. The results of this course are evident in the work accomplished, as shown in the report.

Heavier Fuels Show Lower Mileage and Higher Crankcase Dilution

A paper by Dr. H. C. Dickinson and John A. C. Warner entitled Winter Tests Show Lower Mileage on Heavy Fuels, which was read at the Fuel Session, will be found printed elsewhere in this issue. This paper gave the results obtained by the fuel-consumption and crankcase-dilution tests run jointly by 10 companies in cooperation with the Research Department. This program, which was substantially a repetition of the one put through last summer and reported at the 1923 Annual Meeting by V. H. Gottschalk, included the results of observations on a total of about 57 cars, covering 226 car-weeks of running, and a total distance of over 50,000 miles of running under normal service conditions.

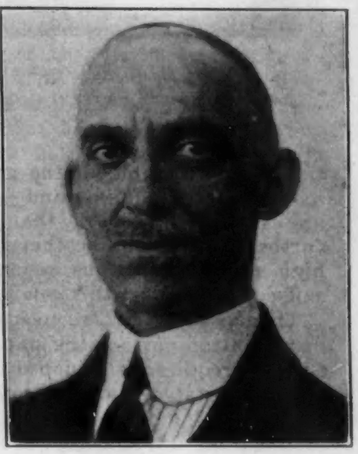
The tests showed a small difference in fuel consumption between the different fuels, the heavier ones giving the lower mileage; a decrease of nearly 20 per cent in the miles per gallon for the same type of car, as compared with the results of the summer tests; an increase in crankcase dilution for the heavier fuels as compared with the lighter ones, and a decided preference on the part of drivers for the fuels having lower temperatures of distillation in the 10 to 20-per cent range of distillation, independent of the volatility near the end-point.

In commenting on this paper Mr. Crane called special attention to the marked preference of the drivers for the fuels of lower initial boiling range as illustrating how readily the average driver can be deceived as to what the engine really demands. The fuel marked □, which has the lowest end-point and is undoubtedly the best or next-best of them all so far as the engine is concerned, was third in order of choice of the drivers, apparently because of its higher initial boiling range.

Spark-Advance in Internal Combustion Engines

G. B. Upton's paper, entitled as above, was read by the author, who showed that spark-timing is one of the important elements in engine performance, which has received less attention than it deserves. The maximum economy of operation requires that the ignition should occur at such a time that the pressure rise takes place one-half before the dead center. This is found to require that three-quarters of the total explosion time shall occur before dead center.

The rate of burning and the total time depend upon both the speed and the load and a good automatic spark-control including both load and speed could increase the economy of service operation by as much as from 5 to 10 per cent. Such a device is practicable and should be less difficult of realization than correct mixture proportioning by the carbureter. The author proceeded with a study of the existing data on



S. M. Lee Dr. H. C. Dickinson

Authors of the Papers Presented at the Fuel Session

flame spread and deduced general conclusions as to the factors affecting it.

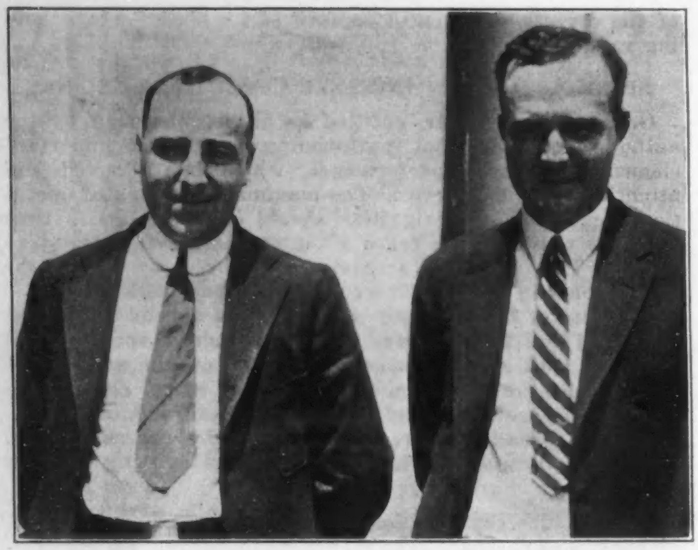
Professor Upton assumed the velocity of the flame spread to be proportional to the time; the distance is then as the square of the time. The assumption is for a typical valve-in-head combustion chamber from which the following conclusion is drawn: the volumetric rate of burning occurs at about three-quarters of the total time of burning. The pressure is slow at first, reaches one-half the total at about three-quarters of the time and drops off at the end. The author discussed the effect of turbulence, concluding that the effect is to produce a linear increase in the rate of flame progress. Engine speed has the same effect, turbulence apparently being proportional to the speed.

The effect of intake suction on the optimum spark-advance was shown by experiment to be independent of the speed. This means that speed and suction control can be made *independent*. The speed function, or the effect of the speed alone on the spark-advance was deduced from experimental results. Combining these two results, it is possible to deduce a turbulence function that may be useful in studying the turbulence effects of different cylinder designs.

The intake-suction effect on the spark-advance is found to depend entirely upon the dilution of the charge, and it is the mass dilution that is the controlling factor. An experimental result of considerable importance in the series of tests is, that the use of anti-knock up to 20 times the usual amount does not affect the optimum spark-advance.

Valuable Points Brought Out in the Discussion

In throwing the session open for discussion of the three papers Chairman Crane said that they all contained so much technical data that all should receive careful study to bring out the real points covered. Regarding the effects of spark-



R. E. Wilson and Thomas Midgley, Jr.
Two Prominent Participants in the Discussion at the Fuel Session

timing, he brought out the point that the mixture is usually too rich in the idling and low-power range, this requiring an even earlier spark than would a normal mixture and further decreasing the thermal efficiency already lowered at high manifold-suctions because the spark is not advanced sufficiently to meet this condition at part throttle.

Thomas Midgley, Jr., took up the statement by the author in the latter part of the paper to the effect that the spark-advance required with doped fuels is the same as with normal fuels and stated that this contradicts the theory propounded by him that anti-knock substances reduce the rate of flame propagation. He said that the amount of tetraethyl lead used by Professor Upton was not abnormal; that for this amount no great difference in spark-timing should be noted and that he would attempt to secure indicator-cards to show exactly what change in the timing is produced by the addition of anti-knock substances.

O. C. Berry was gratified to learn that his own conclusions as to the importance and practicability of spark control for both speed and load were confirmed by a scientific analysis. He described at some length a spark control that he developed some time ago embodying these two features and said that the device was entirely successful, the greatest difficulty met with in the design being with the speed control and not with the pressure control, although the former is in general use.

The greatest practical difficulty in the way of this development is the patent situation. A number of existing patents cover the important features of such a spark control system, but none of them covers enough of the features to serve alone as a basis for a successful mechanism.

S. W. Sparrow called attention to the very slow rate of initial combustion in the cylinder, depending upon the temperature, turbulence and other conditions at the instant of ignition, and questioned whether any such arbitrary figure as three-quarters of the total combustion time could be predicted generally as the correct spark-advance.

In answer to a question by R. E. Wilson, Professor Upton explained that the rate of burning is entirely independent of the initial pressure of the charge. This has been shown for pressures ranging from 1 to over 100 atmospheres, the rate changing by a negligible amount over the entire range. The assumption that the flame velocity is proportional to the elapsed time, as shown in one of the illustrations, is not strictly correct as the rate is not a linear function of the time, but is nearly enough true for the purpose for which it is used, in fact as accurate as some of the other assumptions made.

Mr. Crane described results which he had found with one engine in which the optimum advance was 60 deg. for one plug firing alone and 35 deg. for two plugs at opposite sides of the cylinder, and Professor Upton stated that this exactly confirmed the statement in his paper that the time required for the flame to reach a given point is as the square root of the distance the flame has to travel.

Herbert Chase questioned the reasoning that is based on a definite total time for the completion of combustion, as presented by the author. This analysis refers to the completion of combustion as occurring at a time very shortly after the maximum pressure is produced. Mr. Chase called attention to the visible flames that always issue from an open exhaust at the end of the expansion stroke as an indication that combustion was not even then complete. Professor Upton thought Mr. Chase's eyes deceived him. Some chemical combinations, of course, do occur after the pressure peak and whatever flame may be seen is probably the result of an over-rich mixture or the high temperature of the exhaust.

Replying to a question of R. W. A. Brewer, Mr. Midgley stated that Professor Upton's conclusions checked with his own results. Discussing Mr. Lee's paper, Mr. Brewer suggested that exhaust-gas analyses would offer important additional information as to the relative behavior of different fuels. Mr. Lee stated that if the specific fuel-consumption is the same for two fuels it appears evident that any difference in the needle-valve settings serves only to compensate for the change in the viscosity. As an index to carbureter characteristics, exhaust-gas analyses seemed of insufficient importance to justify their incorporation in the report. Mr. Crane suggested, however, that any exhaust-gas analyses made should be included in the report.

H. L. Horning referred to Mr. Chase's question about afterburning and said that the most important problem is to eliminate afterburning by whatever means may be practicable. Turbulence is one means of digging the gases off the cylinder walls. Valve-in-head engines have little turbulence and require a long spark advance. An L-head engine may have the spark advance reduced from 35 to 4 deg. by a redesign of the cylinder-head. Spark-plug location is one of the most important factors. One interesting result of the fuel work was the data on the effect of viscosity. In cold weather the viscosity far overshadows the deficiencies of our apparatus in vaporizing. Mr. Horning also confirmed Professor Upton's conclusions that the spark-advance depends upon the amount of the exhaust gas.

DANFORTH IS 1923 GOLF CHAMPION

Tournament at Summer Meeting Draws Large Field and Produces Keen Competition

The largest field of engineering golfers ever gathered together in one tournament swarmed over the course of the Spring Lake Golf Club hoping to gather in the honors of being the Society champion for 1923. Close to 150 men played in the qualifying round, and since only 64 could continue in the several tournaments, it was necessary to be more than an ordinary devotee of the Scotch pastime. Nine cards of 90 or less were turned in and one of these was a 78. After the qualifying round the tournament was split into four flights, Championship, Class B, Class C and Class D, there being 16 contestants in each group. Winners in each class were determined by match play.

The semi-final round of the Championship Class found I. W. Danforth facing F. W. Davis and D. R. Meigs arguing with Alfred Reeves. Reeves and Davis succumbed, leaving Danforth and Meigs to fight it out for the medal. The match was a pretty one to watch, both men proving to be entirely out of the average class. The honors were eventually taken by Danforth and he is officially acclaimed the 1923 top-notcher.

G. S. Salzman, H. I. Hiatt, C. E. Dwyer and E. L. Vail worked through to the semi-finals in Class B. Dwyer and Salzman scrapped for the honors, the former winning 1 up in 19 holes. Joseph Bijur and B. S. Gier were the finalists

in Class C, Gier being the top man at the finish. Class D brought the 100 class men together for friendly conflict and J. B. Funk defeated W. H. Wallace in the final round.

Most of the golfers took free swings at the pellet in the man's driving contest on Friday. W. R. Flannery landed in front of all the others and Sanford Brown took second honors. The test of putting skill appealed more strongly to Sanford Brown and he nosed out C. T. Myers and C. H. Foster, who finished in that respective order.

The 1923 Golf Tournament proved conclusively that the Society must select a meeting place where golf facilities are ample. It was fortunate indeed that Spring Lake offered two 18-hole courses or the tournament never could have been finished in the allotted time without interfering with all the other events and meetings on the program.

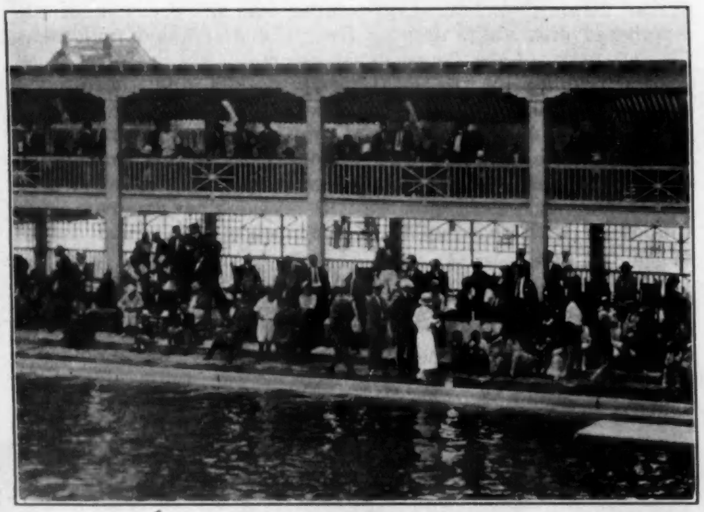
Ladies' Golf Tournament

The golf tournament for the ladies revealed the fact that the lovelier sex are no mean wielders of mashie, driver and niblick. Mrs. George Case, the 1922 winner, was eliminated in the semi-final round by Mrs. Claude Foster. Mrs. George Lees defeated Mrs. F. E. Badger in the other set-to, leaving the finals to be decided between Mrs. Foster and herself. The laurels were eventually Mrs. Foster's in the final contest. The ladies' putting contest was won by Mrs. F. E. Badger; Mrs. Jack Gray was second and Mrs. George Case third.

ENGINEER NATATORS ASTONISH CROWD

Divers and Swimmers Have Great Frolic in Pool of Spring Lake Swimming Club

The Swimming Carnival at the Summer Meeting was the occasion for considerable splashing, spluttering and ripples. It would be considerate to say that a field of very fine swim-



Watching the Swimming Events

mers appeared, but we must be truthful. The facts are that one or two talented research men did give indications of having crawled or trudged before but the balance must be placed in the "old swimmin' hole" class. Gordon Brown and Stephen M. Lee had a little series of two-cornered contests for the first two positions in most of the events. The stunt races tickled the large and appreciative gallery that witnessed the contests. A. K. Brumbaugh gave an all too short demonstration of the antics of youth in the children's pool. The representatives of the Metropolitan Section were after the first places in all swimming events to give them a second leg on the Inter-Section athletic trophy. The summary of the swimming events follows:

33-Yd. Swim (Women)—First, Miss Betty Gurney; second, Mrs. Donald McKenzie; third, Mrs. Ernest Dickey

33-Yd. Swim (Men)—First, Gordon Brown; second, S. M. Lee; third, Rollin Abell

66-Yd. Swim (Men)—First, Gordon Brown; second, S. M. Lee; third, Rollin Abell

Balloon Relay Race—First, Detroit Section

Plunge for Distance (Men)—First, L. C. Hill; second, A. K. Brumbaugh; third, E. Y. Davidson, Jr.

Egg Race (Men)—First, Neil MacCoull; second, Gordon Brown; third, S. M. Lee

Candle Race (Women)—First, Mrs. Donald McKenzie; second, Miss Betty Gurney; third, Mrs. Ernest Dickey

Blindfold Race (Men)—First, Gordon Brown; second, S. M. Lee; third, Neil MacCoull

Fancy Diving (Men)—First, S. M. Lee; second, H. E. Butcher; third, E. Y. Davidson, Jr.

Plate Diving Contest (Men)—First, Gordon Brown; second, A. K. Brumbaugh; third, S. M. Lee

Night Shirt Race—First, Rollin Abell; second, Gordon Brown; third, S. M. Lee

Water Golf (Men)—First, S. M. Lee; second, Neil MacCoull; third, George Briggs

Section Championship Relay—First, Metropolitan (Gordon Brown, Sanford Brown, Neil MacCoull and Ira Snead); second, Detroit

Following the program of Society events Miss Eileen Riggin, youthful diving champion of the world, presented an exhibition of high and low board diving that was a delight to the eye. All of her dives were executed with uncanny precision and grace and put to shame her masculine imitators who had attempted to perform in sylphlike fashion with somewhat ludicrous results. All in all the aquatic program was good sport and seemed to please the spectators.

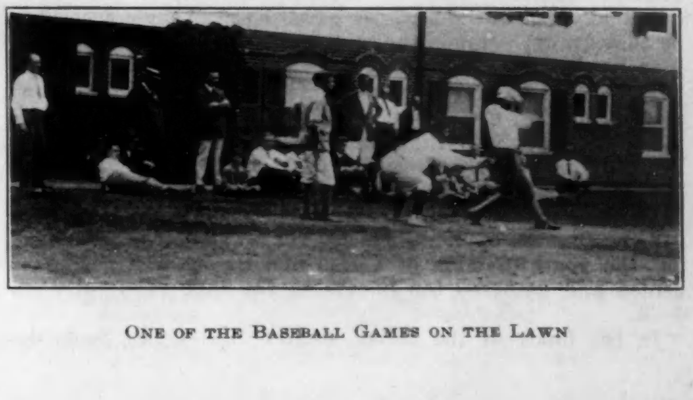
Of course the pilgrimage from the inland sections of the country took numerous dips in the briny and fluttered through the surf. It did not require much coaxing to frolic in the rollers with the temperature scale attempting to reach the century district. There is no denying the fact that Summer Meetings near the water have proved popular.

DETROITERS TAKE BASEBALL SERIES

Win from Harry Figgie's Clevelanders in Hectic Game Featured by Heavy Hitting

The Detroit contingent carried home the baseball cup emblematic of the championship for the year 1923. Neil McMillan, Jr., sprung the surprise of the meeting by organizing and captaining a nine that was able to take the measure of the well-groomed outfit presented by Harry Figgie. This upset prevented the Cleveland Section from taking their second leg on the cup.

The preliminary battles were played on Thursday afternoon. The Metropolitan Section inserted the novelty of having Miss Marie Luhring compete as a member of their nine. Miss Luhring is one of the few women who are members of the Society. The Cleveland crowd threw aside the customary courtesy shown the fair sex and proceeded to lay away the Metropolitan contingent to the unmerciful count of 14 to 2. The Detroiters then took the measure of



One of the Baseball Games on the Lawn

the Indiana-Midwest mixed assembly that had been coached and prepared under the expert tutelage of one George Briggs. The score in this encounter was a little nearer being reasonable, the record showing 6—4.

The final game between the Detroit and the Cleveland Sections on Friday proved to be a contest crammed with exciting moments. The Detroit fielders, George Hunt and Olney Jones, made many spectacular running catches that saved the day. Captain McMillan was engaged in a little mental relaxation in the last inning when considerable business of importance was being transacted by the Cleveland batters. He offset his errors of omission by emulating one Herman Ruth in the final period, neatly parking the indoor ball in the tonneau of a passing car for a complete circuit

Harry Figgie, Cleveland — Neil McMillan, Jr., Detroit

CAPTAINS OF THE TWO TEAMS THAT MET IN THE FINAL GAME OF THE BASEBALL SERIES

of the bases with two teammates preceding him home as company. The final figures given out by the disinterested score computer rate the relative merits of the teams at 8—7.

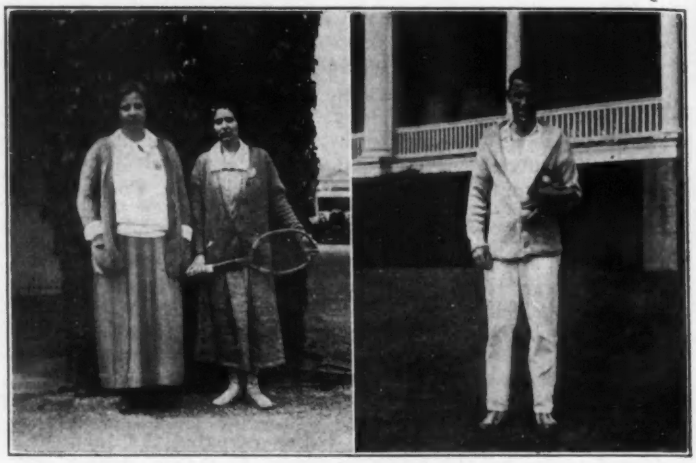
SHIDLE IS SOCIETY'S TENNIS CHAMPION

Also Takes the Doubles Championship with the Assistance of Herbert Chase

The tennis tournament at the Spring Lake Meeting drew out a larger field of entries than that of any previous Summer Meeting. There were many keenly fought matches and one or two upsets from preliminary predictions. Deuce sets and games were plentiful and few of the matches were mere set-ups. There were 30 contestants in the men's singles championship. The semi-final round brought Herbert Chase and Coker Clarkson together in the upper half, the latter winning 6—4, 6—1. Norman Shidle met Stanley Bates in the other half and defeated him 7—5, 6—4, after two very strenuous sets. This left Shidle to face Clarkson in the finals on Friday. The first set zig-zagged for many games but finally fell to Shidle 7—5. This long struggle seemed to be the turning point in the match, for Shidle took the championship honors in the last two sets 6—1, 6—1.

Eleven teams lined up to contest the doubles title and medals. H. M. Crane and C. F. Clarkson had little trouble working through to the finals but Chase and Shidle were hard pressed by the Buettner-Bates combination, the final score being 6—0, 8—6. The finals were witnessed by a large and enthusiastic gallery and provided some first-class tennis for the fans to applaud. Every set was contested warmly, but the youthful team of Chase and Shidle was not to be denied and gathered top honors to the tune of 6—4, 6—4, 6—3.

In the finals of the ladies' singles Mrs. C. F. Scott de-



THE TENNIS PLAYERS

From Left to Right They Are Miss Norma Porter, Runner Up in the Ladies' Singles; Mrs. C. F. Scott, the Winner, and N. G. Shidle, Winner of the Men's Singles and One of the Winners of the Men's Doubles

feated Miss Norma Porter 6—2, 6—0. The mixed doubles final was played by the teams Herbert Chase and Mrs. Ernest Dickey and C. F. Clarkson and Miss Ruth Porter, the latter winning on a come-back after the first set 4—6, 6—4, 6—4.

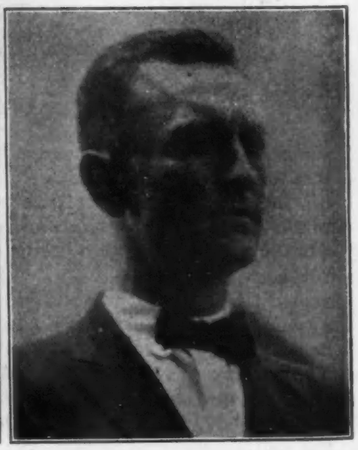
FIREWORKS SHOW FEATURES STUNTS

Metropolitan Contribution Pleases the Members and Townsfolk of Spring Lake

The credit for the most impressive Section stunt at the Summer Meeting goes to the Metropolitan Section. Its fireworks display on Thursday evening was the occasion of unnumbered ohs, ahs and ums from the assembled multitude. The citizenry of the Jersey coast resorts had been forewarned of the display by the local-gossip papers and there must have been 5000 people who enjoyed the pyrotechnic display. The engineering of this stunt must be credited to H. G. McComb, who planned and staged it with his customary efficiency. Rockets, bombs, pin-wheels, floral showers and attractive set pieces pleased the eye. The program was topped off with the display of the Society emblem in letters of colored fire.

The Dayton Section provided a small hydrogen captive-balloon on Friday for those who cared to chance a free ride over the beach. This novel stunt was conceived and carried out by L. L. Custer, whose perseverance was responsible for tracing through the tardy shipment of the material just in time to make good before the close of the meeting. The

H. G. McCOMB



GENE FOWLER

Cleveland Section provided neatly embellished cigarettes at the dinner table to the delight of the members.

The Mid-West Section, reinforced by Phil Overman of Minneapolis and his tuneful banjo-mandolin, put over some acceptable Section harmony during the motion picture show one evening. The parodies used were pointed to indicate that the Chicago organization leads the world and all others are mere triflers. This claim met with some opposition, however.

The Section stunts are an important feature of all Summer Meetings and those presented at Spring Lake kept up the pace set in years gone by.

CREDIT WHERE CREDIT IS DUE

Mention of Those Who Helped to Make the Summer Meeting Successful

The Summer Meetings of the Society are successful largely because of the unselfish labor of certain members who devote time stolen from their own pleasures to direct the many activities. It is appropriate to give these members the credit

T. Milton Who Managed the Entertainment Features

Mason P. Rumney, Who Had General Charge of the Meeting

TWO PERSONS WHO DID MUCH TO MAKE THE 1923 SUMMER MEETING A GREAT SUCCESS

due them as a part of this account of the successful gathering at Spring Lake, N. J., June 19 to 23.

First of all, mention must be made of the Meetings Committee under the able direction of Mason P. Rumney. This

THE STAFF OF THE *Daily SAE*

committee, with the aid of the staff at the New York City office, must handle the principal details of the program. T. J. Litle, Jr., E. P. Warner and O. C. Berry of the committee aided in securing a valuable set of technical papers. Taliaferro Milton managed the entertainment and ladies' events in commendable fashion.

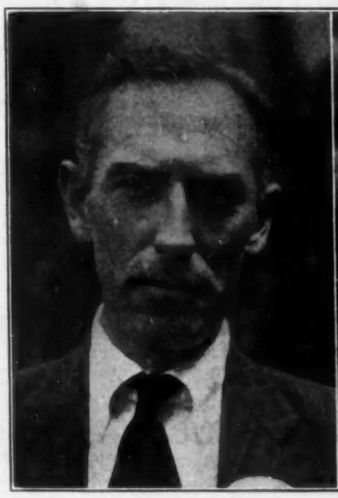
The comprehensive sport program required a number of willing workers, and they did a highly creditable job. The following members of the Sports Committee deserve mention for the complete success of the athletic events:

Sports Committee

Mason P. Rumney, *Chairman*
John Warren Watson—Golf
Lon R. Smith—Trapshooting
Walter J. Buettner—Tennis
Gordon Brown—Swimming
Neil McMillan, Jr.—Baseball
A. D. T. Libby—Horseshoes

The high caliber of the technical papers was mentioned favorably by all who attended the technical sessions. No attempt will be made to commend each author individually, but it should be recorded that their work of preparing and presenting the papers is appreciated by the Council of the Society. The Chairmen are thanked for their part in directing the technical discussions so that the greatest value could be got from them.

The International Motor Co. is thanked for its thoughtfulness in providing three of its latest type motorbuses to transport the members between the railroad station, the golf courses, the hotels and the tennis courts.



John W. Watson Golf

Walter J. Buettner Tennis

Gordon Brown Swimming

Lon R. Smith Trapshooting

FOUR OF THE MEMBERS OF THE SPORTS COMMITTEE

THE ARMY SIX-WHEEL TRUCK WITH BRAKES ON ALL OF THE WHEELS

The head-lamp demonstration staged by the General Electric Co. was most instructive and valuable. It enabled the members to get a complete picture of the progress being made in perfecting anti-glare devices and the manner of applying the Society's head-lamp illumination standard. The United States Army exhibited two of its most recent transport vehicles and these were inspected by a large number of the members. The tire companies are thanked for providing cars equipped with large-section air-cushion tires so that the members had an opportunity to judge the improved riding quality resulting from the use of this equipment. Members were allowed to drive the cars personally to study the effect of the larger tires on steering. Cars of all sizes, from the Ford to the Lincoln and Cadillac, were provided for demonstrating purposes.

The companies who provided cars equipped with four-wheel brakes are thanked for their cooperation in the exhibit program. No formal demonstration was held, but the cars were available throughout the meeting period for members to drive and test as they saw fit. Stopping demonstrations were given by all of the cars immediately following the technical session devoted to the subject of four-wheel brakes. Unfortunately, they were brought to an abrupt conclusion by the interference of a conscientious Jersey State motorcycle policeman who arrested the Renault driver for traveling at a speed of 66 m.h.p. In another instance the local motorcycle policeman threatened the arrest of the driver of one of the low-pressure-tire cars who had been giving a demonstration of the curb-mounting abilities of his vehicle.

THE *Daily SAE* A CLEVER PAPER

The daily paper of the 1923 Summer Meeting was done very cleverly. The Motor Wheel Corporation was responsible for the presence of this newsy and spicy sheet and C. C. Carlton is specially thanked for this display of his interest in the Society and the meeting. The editorial staff was directed by Howard Spohn and E. C. Wright. Fred Wellman acted as chief of the production work and saw many wee morning hours of labor. Gene Fowler, humorist of the Hearst papers, wrote most of the humorous material and was largely responsible for the smiles noted on all faces at the breakfast table. Harry Tarantous, C. E. Heywood and others reported happenings in newsy fashion. The one big feature of the *Daily SAE* which seemed to make the biggest hit was the caricatures drawn on the spot by Henry Major, cartoonist of the Hearst publications. These were adjudged ace high.

One issue of the *Daily SAE* was sent to the entire membership of the Society to let them grasp the atmosphere of the Summer Meeting and decide to be numbered among the attendance in 1924.

SUMMER MEETING ENJOYED BY LADIES

Miss Cramer Again Captures Trophy in the Annual Dancing Contest

There was much ado at Spring Lake for the large representation of ladies present at the Summer Meeting. The social program in charge of Taliaferro Milton and the ladies' sports events left no time for twiddling of thumbs. Bridge tournaments were held each afternoon and attracted anywhere from 25 to 50 ladies. The first prize on Tuesday afternoon was won by Mrs. George E. Goddard, Mrs. E. W. Austin winning the second and Mrs. Ernest Dickey the third. Mrs. Jack Gray was the successful bidder on Wednesday afternoon, Mrs. W. J. Bryan and Mrs. R. S. Lane being second and third respectively. Mrs. Howard Spohn turned in the high tally card on Thursday, Mrs. Goddard being second and Mrs. W. P. Culver third. On Friday morning Miss Lois Culver was awarded the first prize and Mrs. George Kraus the second with Mrs. R. S. Lane running third.

The usual amount of interest was displayed in the annual dancing contest which was held on Friday evening. A large field of steppers competed and it took a long period to narrow them down to three or four of the better Terpsichorean artists. The crowd seemed to be evenly divided in their applause when the contest had narrowed down to two couples. After due deliberation, the judges awarded the first prize to Miss Catherine Cramer who was guided to success by Olney Jones. Miss Clara Wetzel of the Society staff was awarded second prize, her partner being Bernard T. Jones, also of the Society's staff. It was a trick of fate that both male partners in the finals should carry the uncommon name of Jones. Miss Cramer carries the dance trophy back to Detroit for another year.

The attention of the members is directed to an announcement of special importance regarding Part I of Vol. 17 of the TRANSACTIONS that appears on P. 124 of the advertising section of this issue of THE JOURNAL.

Standards Committee Meeting

THE reports of the 13 Divisions of the Standards Committee, which were printed on pp. 565 to 585 of the June, 1923, issue of THE JOURNAL were presented at the Standards Committee Meeting at Spring Lake, N. J., on June 19, and approved as presented or amended in the meeting or were referred back to the respective Divisions for further consideration. The action of the Standards Committee Meeting was approved by the Council and at the Business Session in the evening.

Under an approved revision of the Standards Committee Regulations, the letter ballot of the Society Members on final approval of the reports, will be returnable and counted 21 days following publication in THE JOURNAL of the action taken on them at the Standards Committee Meeting. The ballot on the following reports are therefore returnable to the Society at its offices, and will be recorded on July 23, 1923.

The usual letter ballot form will be sent to each voting member of the Society and will provide for affirmative and negative votes and waivers. Each subject to be balloted upon will be numbered to correspond with the numbers in the following report. In each case the following page references are to those upon which the reports were printed in the June, 1923, issue of THE JOURNAL. This issue should be used in connection with the following record of action taken at Spring Lake and in marking your letter ballot. Each time a ballot is taken there are a number of unsigned ballots returned to the Society, and as these cannot be counted it is suggested that every member casting a ballot read carefully the instructions that accompany it before returning it to the Society.

The following report includes only such changes as were made in the Division reports printed in the June issue of THE JOURNAL, referred to above, that were approved for submission to letter ballot by the members and the principal discussion of each subject in the Standards Committee Meeting.

AGRICULTURAL POWER EQUIPMENT DIVISION REPORT

(1) TRACTOR BELTS AND PULLEYS

(*June issue of* THE JOURNAL, *p.* 565)

AXLE AND WHEELS DIVISION REPORT

(2) FRONT WHEEL MOUNTINGS

(*June issue of* THE JOURNAL, *p.* 566)

The last three columns in Table 2 and footnote 1 were referred back to the Division.

THE DISCUSSION

C. C. CARLTON:—This report, although brief, represents the work of many meetings held by the Division and various sub-committees. Although objections have been made by some of the motor-car builders to the data incorporated in the report, the Division feels that the data conform very nearly to existing practice and that the report is worthy of adoption.

The question has been raised as to the number of flange bolts in wood-wheel hubs as given in the report. The R0 size conforms almost exactly to Ford practice for which six hub-bolts are recommended. For the other sizes of hub, 12 hub-bolts are recommended. Some of the axle manufacturers feel that 6 bolts are sufficient while others think that 8 should be used, but I am very sure that a large number of tests recently made over a period of 1 year particularly by the Hayes Wheel Co. and the Motor Wheel Corporation have proved to the satisfaction of every builder of wood wheels that 12 hub-bolts are necessary for good wood-wheel construction.

The Division, therefore, feels that although 6 and 8-hub-bolts are more nearly general practice today, 12 hub-bolts should be recommended.

On investigating the service department records of several companies using 12 hub-bolts we have found that their difficulties because of 12 hub-bolts are so much smaller than similar difficulties of those using 6 or 8 hub-bolts, that we believe this report is worthy of adoption as S. A. E. Recommended Practice.

H. M. CRANE:—Referring to Table 2, regarding the bolt size and the hub-cap thread I question whether it is not carrying standardization too far to use 12 7/16-in. bolts on four such different size hubs as are recommended, and whether the 3/8-in. bolt would not be ample for at least the two smaller sizes.

The hub-cap thread is plainly a compromise between what the size of the thread ought to be and the ability to use a cheap form of pressed hub-cap. These threads will hold all right if their fit is a good one and the hub-cap is reasonably stiff, but 24 threads for this kind of work is wrong, to my mind. Even 16 threads on the bigger hub-caps is too fine. I think 12 threads is what is really needed to do a first-class job.

Therefore, I move as an amendment to the motion to approve the report, that the number and sizes of bolts the footnote No. 1 and the hub-cap threads be referred back to the Division for further consideration.

MR. CARLTON:—Regarding the hub-bolts I have explained the feeling of those who were building wheels as to increasing the number of bolts to 12. Also by including the footnote "Machine Screw Bolts" we are trying to specify the best possible hub-bolt combination that a long series of tests has proved is what we want and that every builder of wood wheels favors.

Although Mr. Crane's criticism is correct, 12 hub-bolts are much better than 6 or 8. We have found that this is the weakest part of all wood wheels because the first thing that happens in failure is stretching of the hub-bolts. The hub-cap threads is the best compromise that we could make after studying a great many criticisms and suggestions received while drafting this recommendation.

MR. CRANE:—I cannot see why the R1 size hub should require 12 7/16-in. bolts if the same number of the same size are suitable for the R4 hub. I can understand why the wood-wheel makers would like to have them all alike, but it is my opinion that these hub sizes are too different to allow of using the same size and number of bolts. We have had broken front wheels having 10 3/8-in. bolts in which the hubs were not disturbed at all. I will admit they were fairly good bolts of good machinery steel.

GEORGE S. CASE:—I think the trouble in deciding between the 3/8 and 7/16-in. bolts is more a matter of trouble in assembly than the actual performance of the bolts afterwards. As bolt manufacturers we find that 3/8-in. bolts are very frequently broken with a wrench

or injured in assembling where perhaps a 7/16-in. bolt would not be.

ERNEST WOOLER:—Will not the recommendation to use 12 bolts as conventional practice bring them very close together on the bolt circle?

MR. CARLTON:—Extensive tests made during the year have convinced those who have been working on this matter that 12 bolts are really right, the weakest part of a wheel having six or eight bolts being in every case at the bolts. Increasing the number of bolts will add very greatly to the strength of the wheel even with the bolt-circle diameters given and the resultant spacing between the bolts.

MR. CASE:—In specifying a machine-screw bolt do you mean a screw-machine product?

MR. CARLTON:—Yes.

MR. CASE:—If the report refers to machine-screw bolts it does not mean machined screw-bolts, and there should not be a term in the report that does not have definite meaning. With the controversy that is had between using upset bolts of one type or another and the screw-machine product, it would be a little unfortunate to have a recommendation that even a certain type of product should be used. I think I can say after 20 years of making bolts that there is no reason for barring upset bolts from hubs, as they are undoubtedly used on nearly all of the wheels that are made. I have never yet seen a hub with screw-machine bolts.

MR. CRANE:—I intended to refer the two columns, bolt size and hub-cap thread, back to the Division for further consideration; whether they choose to change the size of the bolts or not, I leave to them.

MR. CARLTON:—Should not the number be referred back also?

MR. CRANE:—Yes; all three columns.

MR. CASE:—Will the mover and seconder include that note concerning the machine-screw bolt?

CHAIRMAN BACHMAN:—It has been covered, too, Mr. Case. The situation stands like this: a motion has been made and seconded that the report be accepted. Mr. Crane has moved to amend that motion to the effect that the last three columns headed "Number of Bolts"; "Bolt Size"; and "Hub-Cap Thread" be referred back to the Division. Therefore, if you accept the amendment and the original motion as amended, the report will be affirmed without those last three columns.

There are a number of other combinations that it would be rather hard to go into. The first thing we want to do is to take a vote on the question of amendment. Do you wish to amend the motion to accept by eliminating these last three columns? Those in favor of the amendment say "yes," opposed to the amendment "no." The "ayes" have it and the motion is amended.

Now, we will take action on the question as to whether this report shall be accepted and the motion will be to this effect.

H. S. JANDUS:—I would like to point out that if the number of bolts is changed it may change the bolt-circle diameters.

MR. CARLTON:—The Division has held a number of meetings and done considerable work on this subject, but we will never be able to specify the number of bolts that will suit a great majority of users. The builders of hubs, which involves the axle manufacturers as well as the builders of wheels, feel that there is no one thing more important than to get something near standardization on this subject. Those who want 6, 8 or 12 bolts of various sizes are very determined in their ideas and it may be that we are attempting something impossible of accomplishment through the Society. This standardization is very desirable if it can be done.

ARTHUR J. SCAIFE:—Does the number of bolts have any bearing on the number of spokes used?

MR. CARLTON:—No.

MR. SCAIFE:—The bolts would then go through anywhere in the spoke butts?

MR. CARLTON:—Yes. As a result of the tests already referred to, those who felt that the bolts should pass between the joints of the spokes and those who felt that the bolts should go through the center of the spokes, have almost come to the conclusion that it is immaterial which way they go. The greater majority of the tests, however, show a very slightly increased strength with the bolts passing through the joints of the spokes, which is the reason for specifying the 12 bolts.

(3) TENON HOLES FOR STEEL FELLOES

(*June issue of* THE JOURNAL, *p.* 566)

BALL AND ROLLER BEARINGS DIVISION REPORT

(4) METRIC-TYPE THRUST BALL-BEARINGS

(*June issue of* THE JOURNAL, *p.* 566)

THE DISCUSSION

F. W. GURNEY:—The Ball and Roller Bearing Division re-submits to the Standards Committee the matter of metric-type thrust ball-bearings, which it will be remembered was discussed at the last Winter Meeting. Most of us on the Division have felt that there was considerable misunderstanding then about just what we were trying to do in standardizing the metric-type thrust bearings that we recommended. There seemed to be a very prevalent feeling that the question of the metric and English systems of measurement are involved, but this is not at all what we have in mind. Unfortunately, the standards of ball bearings were first established in Europe, and for that reason they were laid out to metric dimensions. I think we all agree that if we could again lay out a suitable and ideal series of standards for ball bearings, we would make them to English dimensions. We are all working under the handicap of these metric standards that were established 15 or 20 years ago, but the whole industry is based and built upon those standards.

The metric-standard thrust bearings in the report are probably older than the English-standard thrust bearings that were adopted in 1917, I believe, by the Society. We think it is advisable to recognize that there are many companies using the metric bearings and about four firms that are manufacturing them. It is not a question of whether they are better than the others or whether they may be used to so great an extent as the others; it is recognizing the fact that they are being used and to make it more convenient for those who are using and manufacturing them.

R. G. CORNFORTH:—The report states that there were some 416,260 bearings of this type used per year. This is a small quantity compared with the total number of thrust bearings used in the automotive industry. As far as the completion of the S.A.E. Standard adopted in 1918 is concerned, it gives tolerance dimensions for the inside diameter. Is it necessary that we establish all the dimensions for these metric-type bearings? It rather looks as though we established limits and then want to draw these manufacturers into a very unusual standardization.

As for the necessity of having a standard of metric-type thrust-bearings for the users and manufacturers, I doubt very much if it will have much effect with them; they will not change their present designs to use the new bearings in their automotive work.

MR. CRANE:—As I understand it, there is already a partial standardization of the metric-type thrust-bearings printed on pages C39 to C42 of the S.A.E. HANDBOOK and a complete standard for inch-type thrust-bearings printed on pages C34 to C39. The proposal is simply to bring the metric-type thrust-bearings standard into line with the inch-type thrust-bearing standard by completing the already partial standard.

That being the case, it seems to me that the last speaker, if he wishes to be consistent, would move that the present partial standard of metric-type thrust-bearings be removed from the S.A.E. HANDBOOK. I cannot see any reason why we should have a lack of standardization in standards. If we have a certain form of standardization for inch-type thrust-bearings, we should have the same form of standard for the metric type if we are to have any standardization at all.

MR. GURNEY:—All we have now for the metric series is the tolerances that are given for ranges of sizes, while we have complete standardization of the inch thrust-bearings and merely tolerances for the metric series. The whole thing comes down to a question of fact; is the manufacture and the use of metric sizes of sufficient importance to warrant recognition by standardizing them? Are they being used to a sufficient extent so that the users of them need these standards?

MR. CORNFORTH:—Referring to what Mr. Crane said as to the partial standard that we now have, the tolerances are not of so great significance as might be considered, due to the fact that each maker or user will use whatever tolerances he feels are the best for his application of that type of bearing.

H. E. BRUNNER:—The point in connection with the partial standardization of metric thrust-bearings is that there are no standards, but there are in the S.A.E. HANDBOOK tolerances for them. These tolerances refer to those permissible for a given range of bearing sizes, but the standard does not specify what the sizes are.

G. R. BOTT:—This whole subject has been more or less misunderstood. There are some six or eight thrust-bearing manufacturers making metric thrust-bearings that have been used more or less for the last 20 years. It is their desire that these bearings be standardized to the extent that they can all manufacture standard sizes that will be interchangeable. This will help both the manufacturer and the user of the bearings. Originally the metric thrust-bearings were brought over from the European countries, about three makes of them followed one standard, the rest varied in dimensions.

A standard will make it possible for the user to avoid difficulty in the future in getting the same metric thrust-bearing from several manufacturers rather than to be confronted with the difficulty of using a bearing that is not standard.

There is no question of standardizing metric thrust-bearings as opposed to inch thrust-bearings. The manufacturer of metric bearings possibly also makes inch-dimension bearings. It is only a question of standardization. I for one cannot see why there should be any objection to the six or eight manufacturers of metric thrust-bearings getting together and standardizing thrust-bearings so that their tooling will be simplified and they will be able to carry reduced stocks to supply bearings to those who desire them.

Where metric dimensions control annular bearings, there is a desire sometimes to use metric thrust-bearings in conjunction with them. It would be foolish to eliminate entirely or refuse to standardize thrust-bearings because they are not used to such a great extent.

Let me repeat that there are some six or eight manufacturers making thrust-bearings and it is their desire to standardize so that the whole matter will be simplified. There is no question of compelling any one to use metric thrust-bearings in place of the inch-dimension thrust-bearing.

(5) METRIC-TYPE ROLLER BEARINGS

(*June issue of* THE JOURNAL, *p.* 567)

In Tables 4 and 5 the heading for the corner radii was changed to "Corner Radius of Cones" and a footnote added which reads "The corner radius of all cups shall be 1/8 in."

THE DISCUSSION

MR. GURNEY:—The metric-type roller-bearing dimensions reported conform in outside and inside diameters with the light and medium series of annular ball-bearings and the widths with those of the double-row ball-bearings, and are a revision of the standard already adopted by the Society.

T. V. BUCKWALTER:—These metric sizes are being made today in accordance with the tolerances in this table.

PRESIDENT H. W. ALDEN:—In the next to the last column of the tables which refer to "Corner radius, cups 1/4 in., cones," perhaps the statement regarding the corner radius of cups would be better in the form of a footnote at the bottom of the tables rather than in the column headings.

(6) SHAFT AND HOUSING FITS AND TOLERANCES FOR BALL BEARINGS

(*June issue of* THE JOURNAL, *p.* 568)

ELECTRICAL EQUIPMENT DIVISION REPORT

(7) RUBBER BUSHINGS

(*June issue of* THE JOURNAL, *p.* 570)

Numbers for designating sizes were added.

THE DISCUSSION

J. A. KRAUS:—I suggest that numerals be used to indicate the sizes instead of the fractional diameters given in the table. I do not have in mind changing the design in the least, but being able to select from the list by number would facilitate purchasing.

W. S. HAGGOTT:—The suggestion to number the sizes in addition to giving the fractional diameters is good and there will be no trouble in doing so when the standard is printed in the S.A.E. HANDBOOK.

MR. CRANE:—I move, as an amendment to the motion for adoption, that the identification of this list of grommets by suitable numbers or letters be authorized at the time that it is published.

(8) CLIPS

(*June issue of* THE JOURNAL, *p.* 571)

The No. 22 gage for thickness was made minimum, and a note added under the table, which reads, "Clips shall be free from burrs and sharp edges."

THE DISCUSSION

F. W. ANDREW:—At a meeting of the Division this morning, it was decided to amend the report by specify-

ing the thickness, gage No. 22, as minimum, to permit of greater thicknesses if desired. There is also added the note, "Clips shall be free from burrs and sharp edges."

(9) CABLE TERMINALS

(*June issue of* THE JOURNAL *p.* 570)

The upper table in the first column on p. 571 was revised by the Division prior to the Standards Committee meeting as below:

REVISED TABLE FOR ROLLED TYPE STARTING-MOTOR CABLE TERMINALS

Terminal Size	Wire Size, A.w.g.	*A*	*B*	*C*	*D*
4	4	$\frac{5}{16}$	$\frac{9}{32}$	$\frac{11}{16}$	$1\frac{23}{32}$
4	4	$\frac{5}{16}$	$\frac{11}{32}$	$\frac{11}{16}$	$1\frac{23}{32}$
1	2	$\frac{13}{32}$	$\frac{11}{32}$	$\frac{3}{4}$	2
1	2	$\frac{13}{32}$	$\frac{13}{32}$	$\frac{3}{4}$	2
1	1	$\frac{13}{32}$	$\frac{11}{32}$	$\frac{3}{4}$	2
1	1	$\frac{13}{32}$	$\frac{13}{32}$	$\frac{3}{4}$	2
0	0	$\frac{1}{2}$	$\frac{11}{32}$	$\frac{13}{16}$	$2\frac{9}{32}$
0	0	$\frac{1}{2}$	$\frac{13}{32}$	$\frac{13}{16}$	$2\frac{9}{32}$
0	00	$\frac{1}{2}$	$\frac{11}{32}$	$\frac{13}{16}$	$2\frac{9}{32}$
0	00	$\frac{1}{2}$	$\frac{13}{32}$	$\frac{13}{16}$	$2\frac{9}{32}$

Material—Soft sheet copper S. A. E. specification No. 71.

(10) STARTING-MOTOR MOUNTINGS

(*June issue of* THE JOURNAL, *p.* 571)

ELECTRIC VEHICLE DIVISION REPORT

(11) BATTERY TRAYS FOR ELECTRIC TRUCKS

(*June issue of* THE JOURNAL, *p.* 571)

In the table under Fig. 1 on p. 572, the caption "Lead-size and that it is so specified intentionally.
ing of the second column in the table changed to "Range of Jar Widths or Lengths, In. Inclusive." The caption of Table 5 on p. 573 was changed to "Nickel-Iron Storage Battery Trays with Bottoms." The illustrations are to be amplified to show all cell compartments, including blanks where they occur. The tray terminal arrangements are to be changed to show but one terminal in all except the first tray in the upper row and the last tray in the lower row.

(12) CHARGING-PLUGS AND RECEPTACLES

(*June issue of* THE JOURNAL, *p.* 573)

(13) ELECTRIC VEHICLE MOTORS

(*June issue of* THE JOURNAL, *p.* 573)

ENGINE DIVISION REPORT

(14) CARBURETER FLANGES

(*June issue of* THE JOURNAL, *p.* 573)

FRAMES DIVISION REPORT

(15) PASSENGER-CAR FRAMES

(*June issue of* THE JOURNAL, *p.* 574)

IRON AND STEEL DIVISION REPORT

(16) IRON AND STEEL SPECIFICATIONS—PART IX

(*June issue of* THE JOURNAL, *p.* 574)

(17) IRON AND STEEL SPECIFICATIONS—PART X

(*June issue of* THE JOURNAL, *p.* 574)

LIGHTING DIVISION REPORT

(18) BASES, SOCKETS AND CONNECTORS

(*June issue of* THE JOURNAL, *p.* 580)

NOMENCLATURE DIVISION REPORT

(19) RADIATOR NOMENCLATURE

(*June issue of* THE JOURNAL, *p.* 581)

The terms under "Group 2—Radiator" were approved but the definitions under "Group 3—Radiator Core" were referred back to the Division.

PARTS AND FITTINGS DIVISION REPORT

(20) BRAKE-LINING

(*June issue of* THE JOURNAL, *p.* 581)

The fractional negative thickness tolerance for the ¼ and 5/16-in. sizes was changed so that it was expressed in the decimal form.

THE DISCUSSION

F. G. WHITTINGTON:—It is a matter of eliminating sizes that we find have almost eliminated themselves as far as professional practice is concerned, and revising the standard to include sizes that are being used extensively and did not appear in our list.

VICE-CHAIRMAN C. M. MANLY:—Gentlemen, you have heard this portion of the report. Is there a motion for its adoption?

MR. CRANE:—I move its adoption, but I want to ask a question afterwards.

[The motion was seconded]

MR. CRANE:—Has the Division gone as far as I think it could in eliminating overlapping sizes?

MR. WHITTINGTON:—The sizes in the report were verified by three brake-lining manufacturers at the last meeting of the Parts and Fittings Division, in whose opinion the sizes listed are necessary due to the present demand for brake-linings. We would, of course, like to eliminate all the odd sizes we possibly can.

MR. JANDUS:—I recall that there were real reasons for retaining all the sizes listed when the report was passed by the Division.

PRESIDENT ALDEN:—Why are the negative tolerances and no positive tolerance given for the nominal thickness?

MR. WHITTINGTON:—Because the linings will almost always run under rather than over the nominal dimensions, due to the method of manufacture.

H. C. MOUGEY:—Why express the tolerances partly in fractions and partly in decimals?

MR. WHITTINGTON:—We could change that to decimals.

VICE-CHAIRMAN MANLY:—If brake-lining is usually measured with micrometer calipers when it is inspected the tolerances should be given in decimals. It is a question of trade practice, very largely.

MR. CRANE:—I would like to move an amendment to the effect that the Division be asked to make a further study of lining sizes with the idea that at the next meeting of the Standards Committee they may be able to report in favor of cancelling certain of the sizes given in this report.

R. S. BURNETT:—This report is in the nature of a downward revision of the present standard, 10 sizes having been discontinued. In all likelihood when the Division makes a report on brake-lining testing it will take another step in the direction that Mr. Crane suggests.

(21) Rod-End Pins

(*June issue of* The Journal, *p.* 582)

(22) Cotter-Pins

(*June issue of* The Journal, *p.* 582)

The last sentence of the first paragraph of the introduction of this report was deleted.

THE DISCUSSION

John R. Reyburn:—The table in the report specifies no cotter-pin holes, but the introduction given above implies that a 1/16-in. cotter-pin goes in a 1/16-in. hole. I question whether the average cotter-pin will do so. We make a pointed-end type of cotter-pin and have always specified a clearance of about 0.0025 in. on the smallest size. It has been our experience that that is rather a minimum clearance and that for the average cotter-pin, which is not pointed, a larger clearance is required. I think in the past the most popular clearance for that size was from 0.006 to 0.010 in.

Mr. Burnett:—The question of specifying the drill sizes was carefully considered by the Division. The old specification listed "drill sizes." This specification was purposely prepared without any reference whatever to drills, the drill size being left entirely for the user to select according to the clearance that he wants in the hole.

Leonard Ochtman, Jr.:—It says here, "In submitting this recommendation, the Division contemplates that in case the report is approved, all other S. A. E. Standards and Recommended Practices specifying cotter-pins will be brought into agreement with this proposed revision." At present, as I recall, all of the standards and recommended practices specifying cotter-pins specify the size of the hole.

Mr. Burnett:—All of the standards referred to are for particular applications. The proper cotter-pin sizes and their drill sizes will be selected for each of those particular applications and so specified on those standards.

(23) Felt Specifications

(*June issue of* The Journal, *p.* 583)

The paragraph midway in the second column on p. 583 was changed to read "Unless otherwise specified, all of the above grades of felts," etc.

(24) License-Plates and Brackets

(*June issue of* The Journal, *p.* 584)

(25) Taper-Fittings with Plain or Slotted Nuts

(*June issue of* The Journal, *p.* 584)

TRUCK DIVISION REPORT

(26) Motor Truck Cabs

(*June issue of* The Journal, *p.* 584)

The following or a similar footnote was added under the table in the first column on p. 585:

> Inasmuch as the light duty or so-called "speed wagon" type and the heavy duty type of trucks are both made in the 1½-ton rated capacity size and equipped with either general class of cab, the selection of cab dimensions is optional as indicated in the accompanying table.

THE DISCUSSION

Mr. Crane:—Does the report intend that the 1½-ton size come under both classes?

Mr. Burnett:—The Division prepared the report that way purposely because it felt that very many trucks of the speed-wagon type and the heavy-duty type are built in the 1½-ton size, and wanted to leave the selection of either type of cab mounting open on the 1½-ton size.

Mr. Scaife:—At just about the 1½-ton size there is not a very clearly defined line as to what is a 1½ or a 2-ton truck at the present time.

F. W. Davis:—The Division felt very definitely that there are two types of 1½-ton trucks. One is the speed-wagon type to which Mr. Burnett has made reference. The other is the heavy-duty truck. Both types of cab are fitted to that capacity vehicle. It was purposely intended to include both the smaller and the larger sizes as applicable to that size of vehicle.

Vice-Chairman Manly:—It may be well to add a footnote stating that it is recognized as common practice in the truck field to use either cab size on the 1½-ton size and that it is so specified intentionally.

STATIONARY-ENGINE DIVISION REPORT

(27) Stationary-Engine Crankshafts

(*June issue of* The Journal, *p.* 585)

(28) Stationary-Engine Belt-Speeds

(*June issue of* The Journal, *p.* 585)

UNACCEPTED RECOMMENDATIONS

The following reports were referred back to the respective Divisions for further consideration toward presenting them again at the Standards Committee Meeting next January.

AXLE AND WHEELS DIVISION

Front-Wheel Mountings

The last three columns of Table 2 and footnote 1 on p. 566. [The discussion of this subject will be found on p. 79.]

ENGINE DIVISION

Engine Testing Forms

This report, which was printed in the June issue of The Journal on p. 573, was referred back to the Engine Division to consider several changes suggested in the discussion of the report.

THE DISCUSSION

Mr. Burnett:—The report on Engine Testing Forms is a revision of the present standard which has been contemplated for some time. It was completed about a year and a half ago, as I recall it, but was held up pending the report of the Lubricants Division on crankcase oil specifications, the temperatures of the tests being in question. The Lubricants Division has since made its report which has been adopted by the Society, and the engine testing forms have been changed to conform with that report. The few proposed changes and additions to the present forms and sheets as included in this report are submitted as a revision of the present standard to bring it up to date.

Herbert Chase:—The item at the end of the recommendation refers to the change in the ordinates for fuel consumption to read from 0.5 to 1.5 lb. per b.hp-hr. so that four ordinate lines will represent 0.1 lb. per b.hp-hr. It is very inconvenient to have four ordinate lines representing any even number because fractional parts are not easy to read along a curve. Also, as these forms provide for a test at light loads the fuel consumed in pounds per brake horsepower-hour is likely to exceed 1.5 lb. especially at very light loads, and I think on that account the ordinates on this curve should not be limited to 1.5.

There has been a general tendency to go entirely too much on the basis of full-load performance. The average automotive engine is used over 90 per cent of the time at the light loads, and therefore data under these conditions are important.

It seems to me that the forms should also provide for a curve showing the relation between the load and the fuel economy. That is an important characteristic of engines which, in every other industry, is given first prominence, but is too often neglected in the automotive industry. We ought to concern ourselves more with performance under service conditions, which is a light-load condition in the average case, especially for passenger-car engines.

MR. BURNETT:—The testing forms, especially the curve sheet, as at present printed, are somewhat complicated and it has been the desire to keep them as simple as possible, with the idea that where an engineer would want to plot such information he can readily extend the ordinates or even include ordinates for some other curves such as Mr. Chase has mentioned.

MR. CHASE:—Mr. Burnett properly mentions the fact that the Division does not wish to have the forms too complicated. There are good reasons for that, of course, but the difficulty that I see with the average engine test is that it tends along stereotyped lines of full-load performance which is a condition of service that is seldom met with in operation. If we fail to provide or suggest the recording of data at part load, it is very apt to be overlooked entirely. It is really more important in many respects, than the full load.

MR. OCHTMAN:—On specification Sheet B, it recommends adding as item 32 some of the properties of the lubricating oil. It seems to me that this is the wrong place to add this information because this sheet is intended to give the mechanical specification of the engine under test. I believe that specification of lubricating oil and fuel should be put on the log sheet, as there is already space at the head of the log sheet for some of the fuel specifications.

On log sheet C it is recommended that the results be corrected to the standard condition of temperature and pressure. This is very desirable for ready comparisons if tests are to be made under varying conditions, but I do not think it should be included unless space is provided for recording the corrected results.

Aside from the brake horsepower, which is the only one mentioned in the report, there are a number of other items that would be affected, such as the torque, brake mean-effective pressure, indicated horsepower, mechanical efficiency, pounds of fuel per horsepower hour and brake thermal efficiency. It is a question whether on the present size of sheet there is room for all this information in corrected form as well as in the uncorrected form. I think all of these things should be given more careful consideration before this report is adopted.

MR. CRANE:—On specification sheet B, under item 6, there should be added also, if it is desirable to have fan specifications, the number and the pitch or approximate pitch of the blades.

MR. CHASE:—In view of the questions that have been raised, unless there is some pressing need for following the recommendations here, I would suggest that the matter be referred back to the Engine Division with a copy of the discussion here today.

MR. CRANE:—The proposed method of correcting for temperature and barometer is probably correct for barometer so far as most engines are concerned, but as to temperature it is not a fair indication of what the result might be. Some engines with defective heat-distribution would show distinctly better performance at high than at low temperature. Using this form of test and operating at high temperature and correcting back might indicate an apparently much better performance than could actually be got under those conditions.

VICE-CHAIRMAN MANLY:—Would it not be a good thing to draw attention to the fact that these tests have been made at a particular temperature and that there is possibly a marked difference in performance at different temperatures? Snap decision would not then be made in comparing engines without checking up to make sure of their performance at various temperatures.

MR. CRANE:—If anybody wants to know what an engine will do at a given temperature, the safest thing to do is to test it at that temperature.

VICE-CHAIRMAN MANLY:—It might be a good plan in connection with the testing forms to call attention to the fact that the mere test at a particular temperature is not in any way conclusive as to how the engine will perform at any other temperature.

MR. CRANE:—It might be desirable to add a footnote to the effect that on multiple-cylinder engines this correction for temperature is frequently very misleading.

MR. CHASE:—Is it really significant in regard to testing the engine as to just what the viscosity of the oil is at the standard temperature conditions? They are not necessarily the temperature conditions of the oil that is lubricating the engine at the time, and it is the viscosity of that oil which has a bearing on the test results.

NOMENCLATURE DIVISION

RADIATOR NOMENCLATURE

In the report of the Nomenclature Division on Radiator Nomenclature, as printed on p. 581 of the June issue of THE JOURNAL, the Group 3-Radiator Core definitions were referred back to the Radiator Division.

THE DISCUSSION

MR. OCHTMAN:—Under "ribbon cellular core" at the end of the definition, it states "water passage." To bring this in conformity with the rest of the definition it should be changed to "fluid passage."

MR. CHASE:—I would like to suggest that the word "fluid" be eliminated in favor of "water," because the definition refers essentially to water types, the fluid in practically every case being water or largely water. I think the general term "fluid" should be omitted as it can be interpreted under certain conditions as meaning a gas.

MR. WHITTINGTON:—Inasmuch as gases are also fluids, why not have this definition read "liquid" instead of either "water" or "fluid"?

VICE-CHAIRMAN MANLY:—I think it was the idea of the Division that the word "fluid" being the broader term should be used, and I think it is entirely right so far as the nomenclature is concerned. Has there been any reason brought out why they want to separate a water radiator from an oil radiator?

MR. BURNETT:—No.

MR. SCAIFE:—Inasmuch as radiators are also used for steam, it seems to me that the word "fluid" would be in place. Liquid or water would not apply to steam.

MR. CHASE:—These definitions were originally framed and suggested by the Staff of *Automotive Industries*, and they were three in number instead of four. The matter was referred to the Radiator Division and the definitions that are here given were adopted by the Division.

I have held from the start of this subject that the

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reason for this nomenclature is to make clear the difference between the types of core. I believe that the present definitions do not correctly define the cores as they are today, and that they admit of considerable confusion, especially the second definition.

I maintain that this definition applies equally well to the third type as defined here, for the reason that at least in some types of ribbon cellular core, so-called, they consist of an assembly of fluid tubes of several different cross-sectional forms, the tubes being joined together by radiating fins or plates common to all the tubes.

I have brought this matter to the attention of the Division and I have yet to receive a satisfactory reply to this particular objection. The original suggestions on this nomenclature did make it distinct and clear as between the two types. While I am not making a plea necessarily for the original suggestions, I do say that the nomenclature adopted should make it absolutely clear which type is referred to.

If you accept the word "fluid," I have no great objection, but I do object to the term "passages" when tubes are meant. An assembly of passages means little more than an assembly of holes, and one expression would be as nearly correct as the other. I maintain that this type of core is formed of tubes just as the other types are.

The continuous fin and tube type core is defined as "an assembly of fluid tubes of any cross-sectional form, the tubes being joined together by radiating fins or plates common to all the tubes." Some of the continuous fin and tube types are formed in groups of say six tubes. They are not continuous plates, however, and I think there need be no distinction between the individual and the continuous fin. If a distinction is to be made, it should at least cover all present types that are now in general use.

The definitions do not adequately cover the aircraft form of radiators, but refer chiefly to the types used on passenger cars, trucks and tractors.

W. P. KENNEDY:—I am not a member of the Radiator Division, but I do not think there would be any strong objection to leaving these definitions as they are with the prospect of interjecting others. One thing that occurs to me that is wrong here is with reference to where the plate is common to all tubes. Very few radiators are constructed where the plate is common to all the tubes.

MR. CHASE:—I think the matter should be referred back and these differences, which can be easily brought together, straightened out.

MR. KENNEDY:—Mr. Chase seems to think there is no differentiation between the two paragraphs. I think if they are read carefully they will stand out as distinctly different.

MR. CHASE:—I do not mean to say that there is no differentiation. I do say that the second definition covers distinctly the following one. In other words, if a continuous fin and tube core is defined in the way that it is defined in the report, it at the same time defines at least some types of ribbon cellular cores.

The primary reason for this nomenclature was to make a distinction between these types that are essentially very similar, and if this distinction is to be made, we should know when we speak of a continuous fin and tube core we mean what is generally understood to be that, and not something else that comes under the definition. The difficulty now is that two things are defined by the same definition.

MR. CRANE:—My point of view on this discussion is that the Division could work on this for a year and not produce a set of definitions that would not be open to misconstruction by the average engineer. If you asked him to tell you to which class a given radiator belonged, and then asked the same thing of another engineer, they would almost invariably put it in different classes. That will always be the way with anything that merges from one form into another the way the modern commercial radiator does.

MR. CHASE:—The fourth definition is the only one that is not open to serious criticism, as I see it. The first, second and third are incorrect from my point of view for the reason that they overlap more or less and are open to the trouble Mr. Crane mentioned. The fact that today one engineer will call a radiator a fin and tube type and another will call it the cellular type is the very point I make. The reason for this is that there is at present no standard definition. Unless the definitions can make such a distinction, and I believe they can, we might just as well not have them.

ATTENDANCE AT MEETING

The members of the Standards Committee and the Society and the guests in attendance were

Standards Committee Members

H. W. Alden
Azel Ames
F. W. Andrew
B. B. Bachman
George R. Bott
A. K. Brumbaugh
H. E. Brunner
T. V. Buckwalter
R. S. Burnett
C. C. Carlton
George S. Case
W. A. Chryst
E. L. Clark
C. F. Clarkson
H. R. Cobleigh
H. M. Crane
F. W. Davis
W. E. Dunston
George E. Goddard
W. E. Gossling
F. W. Gurney
W. S. Haggott
O. H. Hamm
George W. Harper
C. E. Heywood
M. C. Horine
Herbert S. Jandus
L. S. Keilholtz
William P. Kennedy
C. T. Klug
J. A. Kraus
B. M. Leece
A. D. T. Libby
C. M. Manly
H. C. Mougey
C. T. Myers
A. J. Neerken
John H. Nelson
W. M. Newkirk
George L. Norris
Leonard Ochtman, Jr.
O. J. Rohde
J. L. Rupp
A. J. Scaife
M. H. Schmid
C. W. Spicer
C. B. Veal
J. M. Watson
E. E. Wemp
James A. White
F. G. Whittington
T. H. Wickenden
Ernest Wooler
O. W. Young

Society Members and Guests

Rollin Abell
J. E. Andrew
Robert Atkinson
R. W. Ballentine
C. E. Banta
W. J. Baumgartner
A. C. Bergman
Willard C. Brown
C. W. Burrows
Herbert Chase
W. L. Carver
F. A. Cornell
R. Gardner Cornforth
T. F. Cullen
Luzerne Custer
James Dalton
L. R. Davis
Ernest Dickey
A. M. Dudley
O. E. Eckert
Russell S. Ellis
R. N. Falge
H. H. Gildner
G. Walker Gilmer, Jr.
A. N. Goodfellow
Crosby Gray
C. W. Hartenfels
E. M. Huggins
M. Lair Hull
R. P. Lansing
Marie Luhring
E. G. McDonald
J. F. Marshall
Albert G. Metz
Glenn Muffly
W. C. Munson
W. T. Norton, Jr.
Harry N. Parsons
J. O. Pierce
R. E. Plimpton
John R. Reyburn
O. C. Rohde
J. S. Schneider
C. F. Scott
R. H. Sherry
A. A. Skinner
Lon R. Smith
F. C. Stanley
G. E. Strohm
A. L. Swank
H. W. Sweet
M. George Tigar
Ralph H. Tyler
F. H. Walkley
E. P. Warner
J. A. C. Warner
H. G. Wilson
J. F. Winchester
Chase W. Wolfe

Engineers Lead in Army Intelligence Tests

THE Army intelligence tests were devised during the war to measure natural capacity and intelligence, with a view to selecting for executive positions men who would derive the maximum benefit from special training. These tests did not attempt to measure a man's acquired skill or specific information. They consisted of a number of tasks arranged in series according to difficulty; to each task a certain number of points credit was attached and the final score was given in grades varying as follows: *A, B, C+, C, C—, D, D—, E.* The examination may be termed a test of common-sense.

The accompanying chart, giving in graphic form the relation between intelligence and occupation in the case of 36,500 men, was taken from a report of the office of the Surgeon General of the Army. Using the *D-A* scale at the top of the chart as a basis of comparison, the length of the heavy line following the title of each occupation indicates the range of intelligence of the men engaged in it, while the short vertical line cutting the horizontal line shows the intelligence of the average man in each occupation. It will be observed that different occupations show different degrees of intelligence and that the class which holds highest rank in order of intelligence is that of "engineer officer."

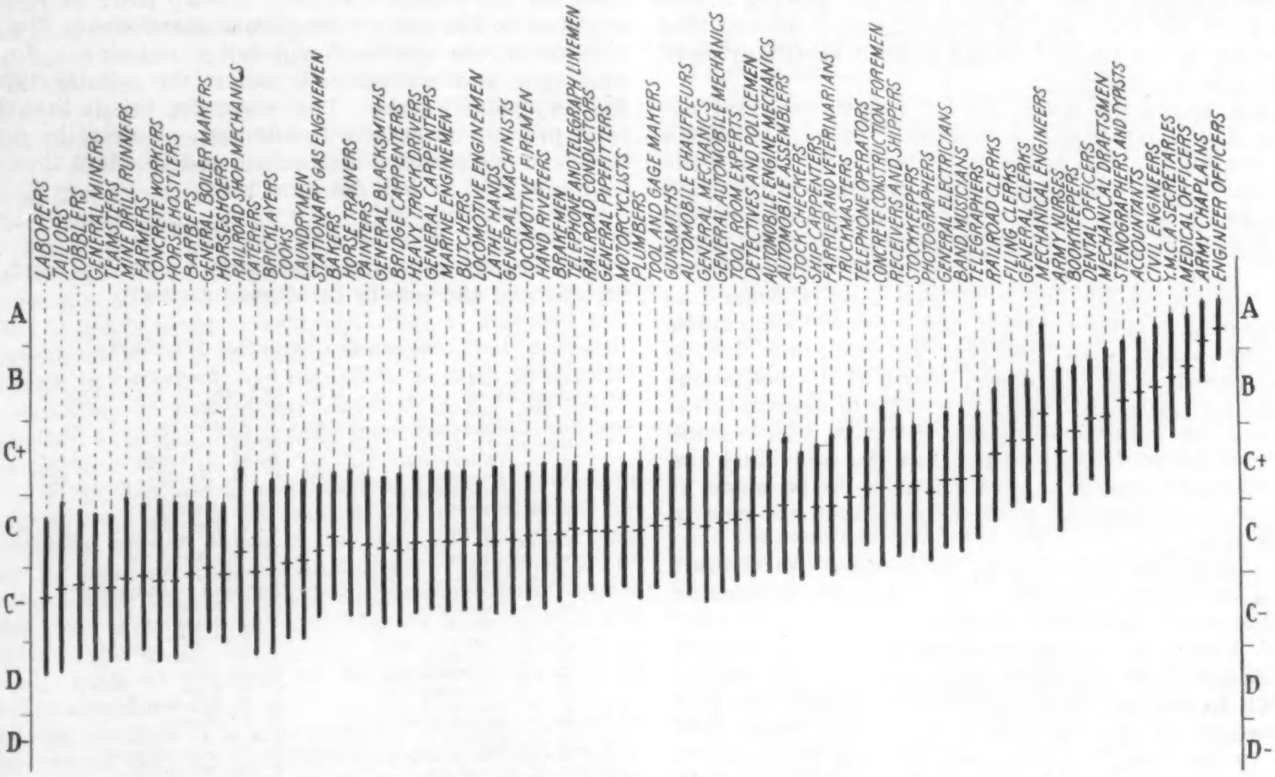


DIAGRAM SHOWING THE RELATIVE BRAIN POWER OF MEN ENGAGED IN DIFFERENT OCCUPATIONS

WHAT "OUGHT" TO BE DONE

ALL of us hear statements that "the society or the profession ought to do so and so." What idea is back of such a statement? Too often it is an idea that the society or the profession is an abstract something, the speaker having no direct connection with the doing of those things, though he may come in for a part of the benefit. When each engineer will speak and think of his society and his profession as "we" instead of "they," and realize that he is speaking and thinking of a group of individuals and not an abstract "it" or "they," the advancement of the profession through society efforts will be certain. Before the engineer can change his status greatly he must think and act as a citizen as well as an engineer.—From a report of a committee of the Iowa Engineering Society.

Vol. XIII July, 1923 No. 1

Winter Tests Show Lower Mileage with Heavy Fuels

By DR. H. C. DICKINSON[1] AND JOHN A. C. WARNER[2]

SEMI-ANNUAL MEETING PAPER

Illustrated with DIAGRAMS

SINCE the road-service tests of the four special fuels supplied by the Research Department, made under 1922 summer-weather conditions, gave results that were deemed inconclusive, arrangements were made for a repetition of both series of tests under the winter-weather conditions of 1923 to determine whether the relative fuel mileages for different fuels are dependent on the temperature at which car operation is conducted. The paper is a report upon the results obtained.

Four fuels that bore a relation to those used in the 1922 summer tests were specified and means adopted whereby knowledge of their quality was concealed from the drivers, special emphasis being placed on crankcase dilution and on general performance as reflected by the drivers' comments. The method of test was, for the most part, that of the summer of 1922, with cars operated as usual by their regular drivers, the filling with fuel and oil and the keeping of records being wholly in charge of the technical staff of the company concerned.

The details of procedure are presented, together with voluminous tabular data, and comment is made. A consistent and important decrease in mileage for the winter tests is apparent. The conclusions reached are stated in detail, as a summary, under six divisions.

LAST Summer 10 companies ran road-service tests of four special fuels specified by the Research Department and supplied by two petroleum refining companies, to determine the effect of fuel volatility on the average mileage per gallon of fuel, under normal service conditions. These results were reported at the 1923 Annual Meeting of the Society as part of the general research program in which the Society is cooperating with the National Automobile Chamber of Commerce, the American Petroleum Institute and the Bureau of Standards, and have been reported from time to time in THE JOURNAL.[3]

The reports of the tests run by the companies under summer weather conditions showed, as did the Bureau of Standards tests, the unexpected result that volatility of fuel within the range tested had no appreciable effect on the fuel consumption per mile, but did have a marked effect on crankcase dilution, the heavier fuels being far worse in this respect than the lighter ones.

It was generally agreed, after the presentation of the results by the Bureau of Standards and those of the service tests of the 10 companies by the Research Department, that such tests run under summer weather conditions were inconclusive as regards year round operation when common experience indicates that heavier fuels are more difficult to handle in winter.

Arrangements were therefore made immediately after the Annual Meeting for a repetition of both series of tests under winter weather conditions to determine whether the relative fuel mileages for different fuels are dependent on temperature of operation and, if so, to what extent.

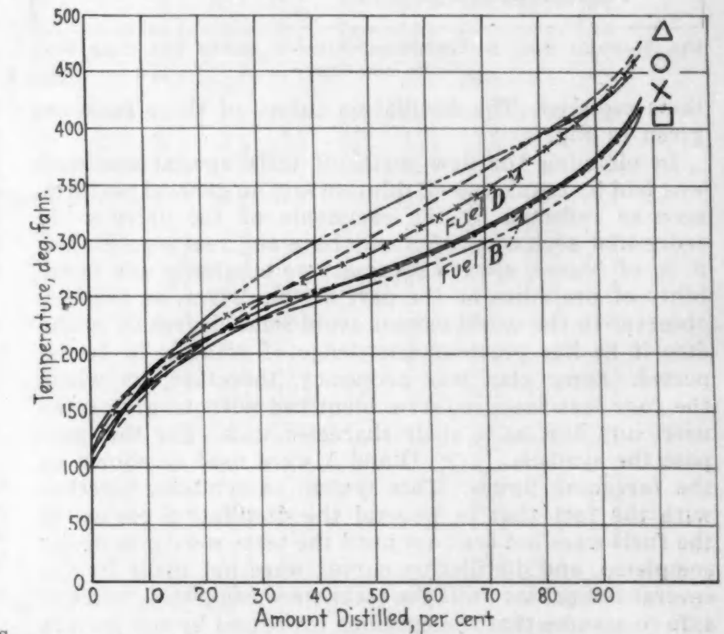


FIG. 1—DISTILLATION CURVES OF THE FOUR FUELS USED BY THE 10 AUTOMOBILE COMPANIES AND OF THE *B* AND *D* FUELS USED IN THE BUREAU OF STANDARDS TESTS

To repeat the series of tests by the several companies required all possible speed in making preparations and securing the necessary supplies of special fuels. The cooperation of the American Petroleum Institute, of the Atlantic Refining Co. and of Cosden & Co. made it possible to get fuels supplied to the 10 companies that agreed to run the tests, in time to complete the work before warm weather came. The universally late spring this year is to be credited with part of the success in this respect.

FUELS

A discussion of the summer tests by the committee in charge of the general fuel-research program resulted in a request by the refiners that the winter tests be arranged so as to make possible a comparison of the behavior of fuels with different initial-points as well as those with different end-points. Accordingly, it was decided to specify four fuels having the following relation to those used in the Summer tests: one fuel identical with fuel *B*; one identical with fuel *D*; one with the same 90-per cent point as *B* but with a lower 10-per cent point; and a fourth with the same 90-per cent point as *D* and with the 10-per cent point like that just mentioned. Further discussion developed the opinion that only very moderate changes in initial-point are practicable. The four fuels finally delivered did not meet the specifications as nearly as was desired but had to be used for lack of time to have

[1] M.S.A.E.—Manager of research department, Society of Automotive Engineers, Inc., New York City.

[2] Assistant manager of research department, Society of Automotive Engineers, Inc., New York City.

[3] See THE JOURNAL, January, 1923, pp. 3 and 118; also February, 1923, p. 139.

RECORD OF CARS IN THE TESTS

Car No.	Age	Total Mileage	When Last Overhauled	Carbureter*	Remarks
1					
2					
3					
4					
5					
6					
7					
8					

Please state whether or not carbureter setting was changed for the different fuels and, if so, the method used for making the settings

* *Note make and model of carbureter*

FIG. 2—FORM USED IN RECORDING PARTICULARS OF THE CARS USED IN THE TEST

them replaced. The distillation curves of these fuels are given in Fig. 1.

In planning the new series of tests special emphasis was laid on crankcase-oil dilution and on general performance as reflected by the comments of the drivers. In order that such comments may have any real significance, it is, of course, always necessary to eliminate any possibility of prejudice on the part of the driver, as the best observer in the world cannot avoid some degree of prejudice if he has previous knowledge of what is to be expected. Some plan was necessary, therefore, by which the four test-fuels could be identified without giving the users any hint as to their characteristics. For this purpose the symbols □, ×, O and Δ were used as shown on the foregoing figure. This system of symbols, together with the fact that in general the distillation curves of the fuels were not sent out until the tests were practically completed, and distillation curves were not made by the several companies until the tests were completed, make it safe to assume that the opinions expressed by the drivers are entirely free from any preconceived ideas as to the fuel characteristics, and are a reliable index to performance, so far as they go.

The engineers of the several companies were asked to keep a record of the oil consumption as well as of the fuel consumption, and to send samples of fuel, of new oil and of used oil from each car at the end of each week's operation to the Bureau of Standards for test. The number of these samples being over 200, only a part of the test results are as yet available and the present report is incomplete in this respect.

RECORD FOR WEEK BEGINNING.............. ENDING..............

CAR NO.	FUEL	MILEAGE, START	MILEAGE, FINISH	MILES COVERED	GAS, START	GAS, FINISH	GAS USED	OIL* USED	OIL SAMPLE MARK	REMARKS

CARS: 1,2,3,4,5,6,7,8 FUELS: A,B,C,D

First Week: 1 and 2 use fuel A; 3 and 4 use fuel B; 5 and 6 use fuel C; 7 and 8 use fuel D
Second Week: 1 and 2 use fuel B; 3 and 4 use fuel C; 5 and 6 use fuel D; 7 and 8 use fuel A
Third Week: 1 and 2 use fuel C; 3 and 4 use fuel D; 5 and 6 use fuel A; 7 and 8 use fuel B
Fourth Week: 1 and 2 use fuel D; 3 and 4 use fuel A; 5 and 6 use fuel B; 7 and 8 use fuel C

**If lubricating oil is changed for each week's run, record the total amount of apparent consumption by substracting the amount drained from the amount put in.*
If any test is made for dilution, enter results under remarks
Retain samples of new oil and each used oil

FIG. 3—WEEKLY RECORD FORM OF TESTS

The method of carrying through this program was the same as for that of last summer except as noted above, that is to say, for the most part the cars were run in groups of 4, 8, or 12. They were selected from among those driven by employes of the companies, either as owner-drivers or regularly employed drivers in the company service. They were operated as usual by their regular drivers without any special reference to the test under way, except that the filling with fuel anl oil and the keeping of records was handled entirely by the technical staff of the company. In each case, the group of cars was divided into four units of one, two, or three cars each, and each unit operated on each of the four test-fuels for one-week intervals, the test thus requiring four weeks with the schedule so arranged that all fuels were in use at all times in an equal number of cars, and that every car used each of the four fuels during the series. One company used a slightly modified form of this schedule that, however, accomplishes the same result of eliminating so far as possible the effects of changes in weather and in individual characteristics of cars and drivers from the final averages, as was explained in the report made last winter.

Figs. 2 and 3 illustrate the arrangement of the forms used for the tabulation of data in the summer tests; the data sheets for the winter tests were substantially the same, with the exception of fuel and car designations.

COMPANIES MAKING TESTS

The ten companies listed below cooperated in the tests. The results from one company have not yet been received by the Research Department, and those from one other firm were not obtained nearly enough in conformity with the generally adopted and recommended procedure to warrant their inclusion in the report.

Autocar Co.
Buick Motor Co.
Dodge Bros., Inc.
Ford Motor Co.
Hupp Motor Car Corporation.
International Harvester Co.
Packard Motor Car Co.
Stromberg Motor Devices Co.
Studebaker Corporation of America.
Waukesha Motor Co.

RESULTS

The mileages covered by the different cars during each week of the test were distributed as shown in Table 1, the greatest number of car-week mileages ranging between 100 and 199. The total mileage, 50,136, was obtained from 226 test periods. The shortest run was 39.8 miles, the longest 1,014.0 and the average 222.0.

TABLE 1—MILEAGE DISTRIBUTION IN TEST RUNS

Distance, Miles	Number of Runs
39-99	30
100-199	108
200-299	40
300-399	20
400-499	13
500-599	10
600-699	2
700-799	1
800-899	1
1000-1014	1

Table 2 gives the miles and ton-miles per gallon for each of the cars for each of the four fuels. The group averages are indicated, and the grand average for each fuel is to be found at the bottom of the proper column.

TABLE 2—MILEAGE AND TON-MILEAGE PER GALLON OF GASOLINE

Fuels / Car No.	Miles per Gallon of Gasoline □	×	O	Δ	Carbureter Adjustments Made	Ton-Miles per Gallon of Gasoline (Load of 300 lb. for passengers assumed) □	×	O	Δ
1	11.1	12.4	14.5	....	?	18.3	20.5	23.9	....
2	12.9	10.7	11.2	12.8	?	21.3	17.7	18.5	21.2
3	16.4	13.6	13.5	14.9	?	27.0	22.4	22.2	24.6
4	12.4	13.8	11.6	11.4	?	20.4	22.8	19.1	18.8
Average	13.2	12.6	12.7	13.0		21.8	20.9	20.9	21.5
5	13.8	8.4	15.5	14.2	?	26.9	16.4	30.2	27.7
6	11.3	12.6	11.9	11.1	?	18.6	20.8	19.6	18.3
7	11.4	12.0	12.3	11.9	?	18.8	19.8	20.3	19.6
8	10.8	....	....	10.9	?	17.8	....	....	18.0
Average	11.9	11.0	13.2	12.2		20.5	19.0	23.4	20.9
9	11.7	10.1	6.6	10.4	Yes	17.7	16.7	11.0	17.2
10	11.1	11.4	11.9	12.4	Yes	18.3	18.8	19.6	20.5
11	11.9	10.1	11.9	10.4	Yes	19.6	16.7	19.6	17.2
12	10.1	10.9	9.9	14.4	Yes	16.7	18.0	16.4	23.8
Average	11.2	10.6	10.1	11.9		18.1	17.6	16.7	19.7
13	11.8	10.6	9.2	12.5	Yes	19.5	17.5	15.2	20.6
14	6.9	7.8	8.0	8.5	Yes	11.4	12.9	13.2	14.0
15	13.3	10.6	10.0	13.4	Yes	22.0	17.5	16.5	22.1
16	14.1	9.4	11.8	10.0	Yes	25.4	16.9	21.2	18.0
Average	11.5	9.6	9.7	11.1		19.6	16.2	16.5	18.7
17	10.0	12.1	9.3	13.2	Yes	16.5	20.0	15.3	21.8
18	7.8	15.4	7.5	8.9	Yes	12.9	25.4	12.4	14.7
19	9.9	10.5	11.0	11.2	Yes	16.3	17.3	18.2	18.5
20	11.4	8.0	9.0	10.2	Yes	18.8	13.2	14.8	16.8
Average	9.8	11.5	9.2	10.9		16.1	19.0	15.2	17.9
21	18.5	13.1	17.7	15.1	Yes	30.3	21.6	29.2	24.9
22	15.0	15.8	20.5	16.2	Yes	24.8	26.1	33.8	26.7
23	10.9	12.7	14.0	18.7	Yes	18.0	21.0	23.1	30.9
24	19.9	15.7	12.9	10.4	Yes	32.8	25.9	21.3	17.2
25	15.9	14.8	18.9	12.0	Yes	26.2	24.4	31.2	19.8
26	13.2	13.9	12.1	10.2	Yes	18.5	19.5	16.9	14.3
Average	15.6	14.3	16.0	13.8		25.1	23.1	25.9	22.3
27	15.5	14.0	12.4	13.7	Yes	22.4	20.3	18.0	19.9
28	14.0	13.4	11.5	12.5	Yes	20.3	19.4	16.7	18.1
29	12.8	13.0	13.1	13.4	Yes	18.6	18.9	19.0	19.4
30	12.6	12.3	12.6	14.4	Yes	18.3	17.8	18.3	20.9
Average	13.7	13.2	12.4	13.5		19.9	19.1	18.0	19.6
31	13.8	13.6	13.3	13.3	No	22.8	22.4	22.0	22.0
32	15.5	15.1	14.5	16.2	No	25.6	24.9	23.9	26.8
33	15.5	15.5	14.7	14.3	No	25.6	25.6	24.2	23.6
34	10.2	9.2	9.0	8.0	No	24.0	21.6	21.2	18.8
35	13.5	15.2	14.6	15.3	No	22.3	25.1	24.1	25.2
36 (a)	11.5	10.7	11.1	11.4	No	....	....	....	....
Average	13.8	13.4	12.9	12.9		24.5	23.6	22.8	22.8
37	11.0	12.9	12.0	11.3	Yes	18.1	21.3	19.8	18.6
38	14.7	15.4	16.5	13.2	Yes	19.8	20.8	22.3	17.8
39	17.6	19.2	13.4	15.6	Yes	25.6	27.8	19.4	22.6
40	11.0	16.6	9.9	10.7	Yes	16.5	24.9	14.8	16.0
41 (b)	11.4	13.5	12.4	13.5	Yes	17.7	20.9	19.2	21.0
Average	12.8	16.1	13.0	13.1		20.1	23.7	19.6	19.4
42	13.8	14.2	15.6	13.8	Yes	24.2	24.9	27.3	24.2
43	11.0	10.4	9.9	9.8	Yes	19.3	18.2	17.3	17.2
44	11.6	11.8	9.8	10.9	Yes	20.3	20.6	17.1	19.1
45	10.9	10.6	9.7	9.7	Yes	19.1	18.6	17.0	17.0
Average	11.8	11.7	11.3	10.8		20.7	20.6	19.7	19.4
46	12.4	12.9	8.0	9.7	Yes	20.4	21.3	13.2	16.0
47	9.7	9.8	7.6	10.6	Yes	16.0	16.2	12.5	17.5
48	11.7	11.4	10.9	11.1	Yes	19.3	18.8	18.0	18.3
49	11.1	9.6	9.9	12.1	Yes	18.3	15.6	16.3	20.0
Average	11.2	10.9	9.1	10.9		18.5	18.0	15.0	17.9
50	19.9	19.7	18.8	14.3	Yes	27.8	27.6	26.3	20.0
51	16.8	15.8	14.5	12.9	Yes	23.5	22.1	20.3	18.1
52	17.4	15.2	16.2	15.6	Yes	24.4	21.3	22.7	21.8
53	17.5	18.3	16.5	17.2	Yes	24.5	25.6	23.1	24.1
Average	17.9	17.3	16.5	15.0		25.1	24.2	23.1	21.0
54	10.6	8.9	17.4	6.7	?	9.5	8.0	15.7	6.0
55	10.0	9.6	9.7	11.7	?	11.0	10.6	10.7	12.9
56	11.7	15.6	12.1	13.7	?	12.9	17.2	13.3	15.1
57	10.0	12.4	14.0	12.1	?	9.0	11.2	12.6	10.9
Average	10.6	11.6	13.3	11.1		10.6	11.8	13.1	11.2
Grand Average	12.8	12.7	12.4	12.4		20.2	19.9	19.4	19.5
90 per cent point, deg fahr.	362	375	420	430		362	375	420	430
Average Temperature deg. fahr. 50 per cent to 97 per cent on Distillation Curve	315	328	380	378		315	328	380	378
Grand Average Miles per Gallon and Ton-Miles per Gallon	12.8	12.7	12.4	12.4		20.2	19.9	19.4	19.5

(a) Special car.
(b) Values combined with those of another car to form group of four for average.

From the grand averages it is noted that the fuels fall into two groups, □ and ×, and O and Δ, according to mileage and less definitely so for ton-mileage. The grand average for miles per gallon on □ and × fuels exceeds that for O and Δ, the less volatile pair, by approximately 2.8 per cent. In ton-mileage, the excess of the more-volatile over the less-volatile pair amounts to approximately 3.1 per cent.

The agreement as to grouping and relative position between volatilities and both mileage and ton-mileage pairs is of interest. The agreement also holds for the values of average volatility between the 50-per cent and 97-per cent points of the distillation curves as can be seen by referring to bottom of Table 2 and to Fig. 1.

While the differences in grand averages of mileage and ton-mileage are not very great for the different fuels, yet the remarkable consistency between these averages and the fuel volatilities as shown at the bottom of Table 2 presents substantial evidence that the average fuel-consumption increases with decreasing volatility under winter conditions.

This conclusion is drawn in spite of the fact that the individual group averages are not in all cases in accord with the grand averages. This is to be expected, considering the fact that some of the tests were run without any readjustment of the carbureter, since under this condition the decreased volatility of the fuel, as shown by the summer tests of the Bureau of Standards, increases the mileage at the expense of performance, the higher viscosity of the less volatile fuels increasing the air-fuel ratio.

A comparison between the results of the summer and the winter fuel-tests is given in Table 3. In this the group averages for cars of a given make and model run in the summer tests are compared with group averages of the same or similar cars of the same make and model in the winter tests. For simplicity the winter averages are given for the two pairs of fuels, while the summer averages are given by only one value for the four fuels. It will be recalled that the summer tests brought out

TABLE 3—COMPARISON BETWEEN SUMMER AND WINTER RESULTS OF MILES PER GALLON

Car No.	Average Miles Per Gallon: □ and × (Winter)	O and Δ (Winter)	A, B, C, D (Summer)
10, 20	10.5	10.9	14.7
9, 18	11.3	8.4	13.8
21, 26	14.9	14.9	16.2
27-30	13.5	12.9	16.6
31-33	14.8	14.4	15.4
42-45	11.8	11.1	13.5
46-49	11.1	10.0	13.0
50-53	17.6	15.8	17.3
Average of Above Values	13.2	12.3	15.1
Grand Average of All Values	12.7	12.4	14.8

TABLE 4—AVERAGE TEMPERATURES IN DEGREES FAHRENHEIT

Car	Weekly Average Lowest	Weekly Average Highest	Average for All Tests
1-8	53	72	65
9-20	29	35	33
27-36	33	44	39
42-53	33	44	39
54-57	33	47	40

practically no difference in miles per gallon for the four fuels.

A consistent and important decrease in mileage for the winter tests over the summer tests is apparent, the greatest difference amounting to approximately 18 per cent between the grand averages. It should be emphasized that these averages are for cars of the same model and in a majority of instances they are the same cars in the hands of the same drivers; hence the 18-per cent increase in fuel consumption may be taken as fairly representative of what is to be expected in average service.

The average temperatures during the tests on several of the cars are given in Table 4.

CARBURETER ADJUSTMENT

The reports of three of the companies made no reference to carbureter setting; it is assumed that no special adjustments were made. One of the companies stated that the tests on its group of cars were run with fixed settings. Four of the companies reported the adjustment of carbureters for the best operation with the fuel in use.

The method used by one of the four was to have the same person make all settings with the object of obtaining maximum power; the basis was to require that the car accelerate from 15 m.p.h., with water temperature at 120 deg. without backfire. One company found it necessary to make a new adjustment for each grade of fuel to obtain the same idling and acceleration performance on the road. A third company adjusted for the best fuel-economy. A fourth company had all carbureters adjusted by the same engineer to have the mixture sufficiently rich so that after running a distance of six city blocks the car would accelerate from 5 m.p.h. without missing or lagging.

COMMENTS OF DRIVERS

Drivers from seven of the companies submitted comments characterizing the fuels with regard to their general driving qualities. The statements of reports naming the fuels in the order of preference have been assembled in Table 5 and are summarized below.

In 10 of the 13 reports on the order of choice first place was definitely assigned to × fuel, while one was undecided between × and Δ; □ was mentioned in two cases. Thus, × fuel appeared for first place in 11 of the 13 reports. For second choice seven of 13 reports definitely assigned second place to Δ fuel, while one was undecided between Δ and ×; □ was mentioned in three cases; and × in two. Thus, Δ fuel figured as second choice in eight of the 13 reports. Four of the 12 reports definitely assigned third place to □ fuel, while three were undecided between □ and O; Δ was mentioned in two cases, and O in one; Δ and O were tied for third place in two reports. Thus, □ fuel appeared in seven of the 12 reports. For fourth choice seven of the 13 reports definitely assigned fourth place to O fuel, three were undecided between O and □, and two between O and Δ; □ was mentioned in one report. Thus, O appeared for fourth choice in 12 of the 13 reports.

In attempting then, to summarize the drivers' order of preference as based on the general driving merits of the fuels, it seems reasonable to assign first, second, third, and fourth place to ×, Δ, □, and O fuels in the order named. It is seen that the two extremes are very definitely decided, while the intermediate choices are more scattered.

Several of the drivers gave more specific opinions as to the starting, acceleration and power characteristics. These, in general, indicate agreement with the order of preference above stated. Extracts from several reports are given below in Table 6.

Referring to the distillation curve shown in Fig. 1, it is interesting to note that the order of preference follows the order of volatilities from the 14-per cent point to the 20-per cent point of the curves. This range appears to determine the starting and acceleration characteristics. The order of preference is largely determined by starting characteristics, and relatively small differences in volatility in this range have a marked effect.

CRANKCASE-OIL DILUTION

Samples of the new and used oils were sent to the Bureau of Standards for test. The results of these tests, so far as completed to date, covering 22 of the cars are shown in Table 7 arranged according to groups and car numbers.

As in the summer tests, the dilution is found to increase in general as the volatilities decrease. The O and Δ fuels are substantially the same. These two fuels have the same 80-per cent point on the distillation curve and the relative volatilities reverse at this point. Furthermore, it is to be noted that □ and × and O and Δ, are grouped roughly in pairs and that the dilution for the less-volatile pair, O and Δ, exceeds that for the more-volatile pair, □ and ×, by approximately 43 per cent.

The Saybolt viscosities of the samples of used oil are also given in Table 7. The grand averages run 125, 115, 82, and 81 sec. for fuels □, ×, O, and Δ, respectively.

CONCLUSIONS

Twelve of the larger companies, in cooperation with the Research Department of the Society of Automotive Engineers, in carrying through the two series of fuel-consumption tests last summer and last winter, have accomplished a result that could scarcely have been secured in any other way, and have demonstrated the practicability of such joint action on problems that are of sufficient importance to the industry as a whole to warrant the expenditure of the very moderate amount of time and money involved by each of several companies.

The two series of tests, including observations covering nearly 500 car-weeks of driving under summer and

TABLE 5—DRIVERS' COMMENTS BASED UPON OBSERVATIONS OF DRIVING CHARACTERISTICS

First	Second	Third	Fourth
×	□	△ or O	O or △
× (*c*)	□ (*c*)	△ (*c*)	O (*c*)
× (*d*)	△ (*d*)	□ (*c*)	O (*d*)
× (*d*)	△ (*d*)	□ (*d*)	O (*d*)
× (*d*)	△ (*d*)	□ (*d*)	O (*d*)
× (*d*)	△ (*d*)	□ (*d*)	O (*d*)
× (*d*)	□ (*d*)	—	O (*d*)
□ (*c*)	× (*c*)	△ (*d*)	O (*c*)
× or △ (*c*)	△ or × (*c*)	□ or O (*c*)	O or □ (*c*)
□ (*c*)	× (*c*)	△ or O (*c*)	O or △ (*c*)
× (*c*)	△ (*c*)	□ or O (*c*)	O or □ (*c*)
× (*c*)	△ (*c*)	O (*c*)	□ (*c*)
× (*c*)	△ (*c*)	□ or O (*c*)	O or □ (*c*)

(*c*) Carbureter adjustment made.
(*d*) No adjustment of carbureter made.

winter conditions, with the observations arranged to eliminate so far as possible the effects of weather and individual differences, afford a most reliable basis for conclusions as to the behavior of different fuels in the hands of the average driver.

So far as mileage alone is concerned, *under summer conditions* there is no important difference between the average mileages secured per gallon of fuel, as between the fuels tested.

Under winter conditions there is a small but definite increase in average fuel-consumption of about 30 per cent accompanying an increase of about 55 deg. in the 90-per cent point of the distillation curve. Taken by itself, this relatively small difference in mileage is unimportant

TABLE 6—EXTRACTS FROM DRIVERS' REMARKS

Car No.	□	×	O	△
1 to 8 inclusive			Practically unanimous complaint against these fuels.	
9	Excellent. Lots of pep and pull.	Same as ordinary commercial gasoline. Fairly good pull and pep.	Very poor. Hard starting. No pull or power.	Little better than O.
10	Difficult to start when cold but O. K. when hot.	Same as △.	Engine would not run smoothly until after 3 or 4 miles. Seemed to be adjusted for too lean a mixture.	Same as ×.
11	Best of four—Like ×. Best acceleration.	Better than △ considerably. No trouble in starting or running.	Like △. Same trouble in starting but not so much knock. No preignition.	Hard to start. Used hot water on manifold. Knock after warming. Preignition once.
12	More or less trouble. Needed to adjust carbureter using choke.	Trouble with starting. Slight knocks. No hot water needed in starting.	Better than ×. Practically no difficulty with this grade.	Satisfactory; little or no difficulty.
13	Only difference noted was that car was hard to start.			
14	Extremely cold weather and could not start without applying hot water.	No difficulty in starting. Ascribed to warmer weather.	Started much better than any other. After warm was as good as any gasoline.	Better than □ but not as good as should be in starting.
15	Same as O.	Same as △.	Great difficulty in starting.	Very little difference from regular gasoline.
16	Poorest action. Less mileage. Harder starting. Sluggish and little speed.	Performance in starting and running similar to commercial gasoline.	Much slower starting and less mileage. Plenty of power after heated.	Very much like ×.
17	Had no trouble and could detect no differences.			
18	Noticed no difference.	Not so much pick-up and power as with □ and ×.	Not so much pick-up and power as with □ and △.	Noticed no difference.
19	More trouble in starting. Tendency to back-fire after turning off ignition.			Good performance. No difference compared with previous operation.
20	Sometimes necessary to wait a minute or so before enough power to start. Poor pick-up.	Worked well, started easily, picked-up well.	Started well but did not pick-up rapidly.	Same remarks as ×.
21 to 26 inclusive		Best starting. Leanest carbureter setting.		Poorest starting. Richest carbureter setting.
27 to 30 inclusive			Drivers all complained of trouble in warming up and getting started.	
37 to 41 inclusive	Very satisfactory; almost as good as ×.	Very good for starting, warming-up and acceleration.	Extremely bad; most of drivers protested against using it.	Less satisfactory than gasoline ordinarily used, but better than O.
54	Good starting power when warm.		Hard starting; no power till warm.	Good starting and power.
55	Good starting.	Very easy starting.	Same as above.	Hard starting.
56	Hard to start; good power when warmed.	Easy starting; no acceleration till warm.	Fairly good starting.	Hard starting.
57	Good starting.	Hard starting.	Hard starting; no power till warmed.	Hard starting; poor running till warm.

compared with the estimated difference in the relative amounts of the two extreme grades of fuel from a given quantity of crude oil.

The results on crankcase-oil dilution are not complete, as only part of the samples have yet been tested. So far as they go, however, the tests show an increasing amount of dilution and a corresponding decrease in viscosity of the oil after use, as the fuel volatility decreases.

The average of results at hand shows an increase of 43 per cent in the amount of dilution with fuels differing by 55 deg. at the 90-per cent distillation-point, and for the viscosities in Saybolt seconds at 100 deg. fahr., of 300 for the new oil and of 125, 115, 82, 81, the average viscosities at the end of a week's run, for each of the four test-fuels respectively.

Differences in starting and general performance as noted by the drivers correspond with the relative volatilities of the fuels in the range of 15 to 20 per cent of the distillation curve. The drivers chose the fuels having the highest and the lowest distillation-temperature in this range with remarkable consistency, notwithstanding the small differences that exist in this range.

TABLE 7—CRANKCASE-OIL DILUTION

CAR NUMBER	Fuels Used							
	□		×		O		△	
	Dilution Per Cent	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution Per Cent	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution Per Cent	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution Per Cent	Viscosity at 100 Deg. Fahr., Saybolt Sec.
New oils	....	300	....	300	....	300	....	300
9	20.8	90	22.0	77	22.3	65	28.5	65
10	12.5	129	18.5	97	27.7	69	31.5	66
11	14.0	123	15.8	108	21.5	85	21.5	90
12	21.5	79	12.0	90	33.6	59	15.7	122
Group 3 Average	17.2	105	14.1	93	26.3	70	24.3	86
13	19.5	92	35.0	55	13.8	82	27.0	47
14	10.5	127	14.2	125	20.8	89	20.0	92
15	28.0	176	23.0	87	13.0	128	14.0	129
16	15.0	112	17.0	102	25.5	78	9.0	66
Group 4 Average	18.3	127	22.3	92	18.3	94	17.5	84
17	18.0	95	17.5	97	17.5	103	22.8	83
18	9.0	149	19.8	93	29.0	64	22.8	78
19	13.3	130	12.6	120	19.3	98	21.5	90
20	24.0	70	29.0	63	42.0	47	36.5	53
Group 5 Average	16.1	111	19.7	93	27.0	78	25.9	76
21	5.5	140	6.3	159	11.4	111	16.5	78
22	7.8	141	7.6	149	14.8	104	15.5	95
23	8.1	140	7.5	154	12.3	104	20.5	82
24	12.5	128	9.9	138	23.6	73	24.8	69
25	7.2	156	7.7	149	23.0	75	22.4	78
26	9.4	134	8.6	137	18.9	90	22.7	74
Group 6 Average[4]	8.4	140	7.9	148	17.3	93	20.4	79
27	11.0	165	9.5	199	22.0	83	26.3	79
28	11.2	132	20.0	95	48.6	44	27.7	71
29	14.0	112	14.5	107	29.0	66	32.0	63.
30	....	....	13.5	120	22.5	75	9.7	104
Group 7 Average	12.1	136	14.4	130	30.5	67	23.9	79
Grand Averages	13.9	125	15.5	115	23.3	82	22.2	81

[4] Determinations of this group supplied by manufacturer: others obtained from Bureau of Standards tests of samples.

ANALYSES OF NEW OILS

Used in Cars	Gravity		Flash Point, Deg. Fahr.	Fire Test, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.
	Specific	Baumé			
Groups 3, 4, 5	0.935	19.6	355	395	300
	0.935	19.6	345	400	301
Group 6	0.907	....	...	...	297
Group 7	0.932	20.2	355	420	306

The Factory Engineering-Staff and Its Relation to Service

By J. W. Lord[1]

METROPOLITAN SECTION PAPER

SERVICE problems, fundamental in character, that must be solved at the point where the vehicle is designed and produced are the only ones considered, and all of them involve the factory engineering-organization. The author states an existent feeling in the service field that the factory engineers are inclined to be arrogant and obstinate, almost invariably taking the attitude that a difficulty is likely to be due to anything except design, material or workmanship; but he believes this situation will disappear as the factory engineer takes more interest in service problems and comes more closely into contact with service and maintenance.

The problems due to inaccessibility of parts, repairs and repair parts are discussed, and the influence that the factory engineer has and can have on service are treated in some detail. A recommendation is made that engineers be given greater opportunity to see the product in the field.

THIS is a broad topic and, before giving thought to it directly, I believe it well to analyze briefly why service is being pushed so much into the foreground today, its place and value in the automotive industry and the problems it involves. The real reason service is becoming of such importance is that the public is demanding better, cheaper and more prompt repairs, and showing preference for those who will make them, just as it demanded greater reliability earlier in the history of the industry and, later, reliability at a lower first cost. The public realizes that the majority of cars of today are fairly reliable and that, so far as car value is concerned, one gets about what one pays for; but the public is also becoming educated to the automobile as a machine that wears, and it realizes more and more that maintenance has not received the close study that has been given the product from the performance and production angles. I believe the builder who can sell the most miles per dollar of reliable car or truck transportation is the one to whom the public will come with transporation problems. An honest, well-designed and well-built machine cannot fill this requisite by itself. It must be backed by facilities for prompt, honest, well-made repairs of the stitch-in-time variety and those of more extensive nature, that become necessary as the car mileage runs up.

We often hear an owner say that his car is a fine machine but that it costs a fortune to keep it running. Distributors are having this thrust at them every day and more than ever recognize that good service, better, cheaper and more prompt maintenance or service are prominent and powerful selling factors. The customers' purchase of transportation is not complete without them. This is the value of service and its place in the industry.

Henry Holt, former president of the Automotive Service Association, said that our whole aim in service work should be to sell more cars by making them fulfill the purpose for which they were made. The service-station must cooperate with the sales end of the organization to sell more cars; it must make the cars give the greatest of satisfaction, so that when people need new cars they will come back and get them.

There are many problems of service, one class of which require local solution and do not directly involve the factory, but there are service problems, fundamental in character, which must be solved at the point where the vehicles are designed and produced. It is only this latter class that need be considered in this paper, and all of these problems involve the factory engineering organization.

Service-stations must primarily do their utmost to keep the product on the road, whether this involves making the usual normal repairs or making emergency repairs necessary because of faulty design, workmanship or material. Repairs of this latter variety demand much of service, particularly when a truck is involved. The job must be put on the road again with all possible speed. It seems at times that the more successful a service-station is in making such repairs, the less attention is given by the factory to the real cause of the trouble. Sometimes such difficulties are allowed to gain great headway and, when the engineer finally does realize that a serious condition has arisen, which must be taken care of, it can only be done at most heavy expense. That such things can and do happen and can continue, is difficult to explain. Perhaps many an engineer feels that the average service-station loudly cries "wolf" whenever any difficulty, no matter how trivial, first appears. On the other hand, there is a feeling in the field that the engineers at the factories are inclined to be arrogant and obstinate; almost invariably taking the attitude that a difficulty is due to anything except design, material or workmanship. I believe this situation will disappear as the factory engineer takes more interest in service problems and comes much more closely into contact with service and maintenance.

ACCESSIBILITY AND REPAIRS

The problem of accessibility in making repairs deserves the attention and the continuous study of the factory engineers. To customers and their chauffeurs some repair jobs seem to take an unnecessarily long time, often due to the job being within easy vision but most inaccessible. The service-station may convince the owner that under the circumstances, the time was reasonable; but when the bill has been paid, the owner feels he has paid more than necessary for a simple repair and, fundamentally, he is right. This matter has been well presented by B. M. Ikert and others and I need not enlarge on it. I only repeat, accessibility is a maintenance problem to be handled at the point of production.

The matter of selling repairs also deserves the attention and the study of the factory engineers. I believe flat-rate service to be the most satisfactory method of selling maintenance, and that it will become general. The rate should cover the finished job, both labor and material. A flat labor-rate only sets up a situation that places a premium on using new parts, rather than ex-

[1] M.S.A.E.—Service manager, Harrolds Motor Car Co., New York City.

pending slightly additional labor to repair old parts. The final charge to the customer is likely to be higher for the flat labor-rate plus the cost of the material, than where a flat charge is made for the job.

For some time we have been submitting estimates in our service work. During the last several years, I have put in equipment for making repairs to parts that is cutting the cost of jobs appreciably just by saving parts; whereas, if there were no incentive to save parts, as with just a flat labor-rate, I doubt whether we would have gone as far as we have gone.

Flat-rate service depends on being able to do the same job on any car or truck of given make and model in approximately the same time. This can be done when the repair-shop is equipped with the proper tools and provision is made in the design of the vehicle to permit the use of these tools, such as universal pullers and the like. When provision is made in the design for the use of special and universal tools, it makes little or no difference in the repair time whether or not a spring bolt or other part is frozen in place; the puller will quickly take it out anyway. A job stumps the repair-shop when no provision is made to apply pullers or some odd, last-minute provision is incorporated after the job is in production which requires making up a new and special tool. In other words, the factory engineer should be interested in repair tools and their application. He should be interested in accessibility. These are not problems to be dismissed by taking the attitude or presenting the argument that it is undesirable to build vehicles that every tinker can readily take apart or put out-of-order, and that come apart so easily that they will not stay put. These are problems in design in which the engineer should be so interested as to give them equal consideration along with design from performance and from production angles.

Repair Parts

The matter of repair parts also holds much of interest for the factory engineer. Prompt repairs usually involve having the necessary repair parts on hand. This involves carrying parts for the current cars and for the older models as well, and leads to a heavy inventory of many different parts. A study of applying later parts to earlier models will often result in effecting many substitutions all tending to simplify the stock and make it more effective. It is not only necessary to have the parts on hand, but also an up-to-the-minute catalog of these parts is most essential, a catalog which, by its arrangement, makes it possible for the average repairman to identify the name and the number of the part he needs quickly and accurately.

We hear much about pirate parts and substitute parts and, in the same breath, that they are far inferior to the genuine article. The fact remains that the makers of these parts are doing a growing and flourishing business, from which we can draw the conclusion that, in spite of the loudly proclaimed inferior quality, their products give fair service. Naturally, their success is most evident in the large centers of distribution where they have made such headway that there is a backfire to the term "pirate parts," and here and there the question is raised as to who the real pirates are. This matter of high-priced repair parts places the service-station using genuine parts at a decided and sometimes ugly disadvantage with the repair-shop that buys other than genuine parts. No one likes to be charged unjustly with extortion, and to realize that high material charges are driving away good customers. There are some expensive parts replacements where some small part of a comparatively large unit is worn or broken. Provision should be made to take care of the wear without replacing the entire expensive part. The factory engineer is in position to do much to improve these parts problems. The foregoing briefly outlines some of the service problems to be solved at the factory.

The Factory Engineer's Influence

So far as the factory engineer is concerned, it seems to me that the industry has gone through two distinct engineering phases and is entering a third. I call them engineering phases because I believe that the further development of the industry lies in the hands of its engineers. The first phase was to design an automobile that would run, that would perform. The second was a further development of the first, coupled with design to facilitate production. The third was a further development of the first two, coupled with design to facilitate maintenance.

It is only natural and to be expected that the factory designing-engineer is fully in accord with design from a production viewpoint as well as that of performance. Production interests are right at hand. The production engineer is always at his elbow, continually showing him how a slight alteration of the design will not affect the performance but will simplify production and reduce costs. By virtue of this continual contact, the designing engineer becomes somewhat a production engineer himself. On the other hand, maintenance and repair have been far afield. They have not been physically close to the engineer. They have been brought to his attention by cold, indifferent reports that normally do not make the vivid impressions that come from first-hand contact, a contact that can be obtained only by traveling and spending time right in the service-stations and in close contact with the repair work just as it comes in.

Some companies have developed an engineering group in their service departments. Such a group can follow closely the performance of the company's product in the hands of its customers. From various sources of information, such as roadmen's reports and letters, distributors' reports and letters, parts returned claimed defective and parts orders, they can gather statistics giving an index of what is happening and, by periodical reports, can inform the management and the engineering and the manufacturing departments of what they find. It is possible for them to go much further and develop tools and repair methods and collect various data regarding repairs to older models that today each individual distributor's service-station is working out for itself at great expense. I believe all this is good organization, and a step in the right direction. Such a group is constituted of the logical ones to work with the chief engineer on matters of accessibility and on design to facilitate rapid repair, to insure the use of standard tools and the like, but its members will not work in the closest of harmony with the designing engineer until he gets away, sees maintenance and service as actually rendered to the public and realizes the vast possibilities for improvement that the dominant position he holds makes it possible for him to initiate, and until it is his intense desire to develop this phase of the industry.

I believe the designing engineer needs this intimate contact with service and that the factory management which will see to it that its engineers get this intimate contact with maintenance will be amply rewarded by a product that will give less trouble in the hands of its owners and one that can be maintained at less expense.

Such a product is bound to reflect itself in a reduced policy-account of charges absorbed for making-good on defects developing in the field.

I think that there is a tendency to hold the designing engineer much too closely to getting out the department drawings, so that he becomes not much more than a chief draftsman. I suggest an organization involving an assistant executive-engineer who can push the department work along, giving the chief time to get away and secure first-hand knowledge of maintenance or repairs and of service-station problems. I fully believe that with this intimate contact will come a knowledge and realization of service almost unknown today, which will be so real and so much a part of the engineer that his work in design will reflect it to the benefit of the industry, just as his intimate contact with production led to the rapid development of the industry. It seems to me that this will never happen until the engineer is as familiar and in as close contact with the problems of service as he is with those of production. For the good of the industry, its engineers should take more opportunity and be given more opportunity to see the product in the field.

L. J. Eastman remarked that the service man is a sort of younger brother. That is a very fine way of putting it and, speaking as a younger brother, I say that we want our older brothers to get much closer to our problems. They will help us and, we believe, in doing that, they will help themselves and the industry as well.

THE DISCUSSION

B. B. BACHMAN:—Probably no one is more thoroughly in sympathy with the idea of service and what it means to the industry than I am. I have fortunately been associated with an organization that has attempted to build the foundations of its business upon a satisfactory service organization and a complete service plan. We have had some opportunities of doing things, in the type of organization which we have used, that not everyone can follow who does not have the same type of industrial organization. The fact that a very large percentage of our product is marketed through our own branches places the engineering department in a very much closer contact with the people who are selling and servicing the product than I can conceive possible with a distributor organization involving multitudes of independent individuals.

C. B. VEAL:—The problem resolves itself almost entirely into one of management; it is not a difference of opinion between the engineers and the service-men themselves.

J. G. VINCENT:—I think Mr. Bachman is absolutely right when he states that one of the biggest values of the flat-rate system of service charges lies in the necessity for carefully analyzing service operations from a cost viewpoint. To this I would add a corollary to the effect that such analysis in any line of business almost invariably results in a great gain in efficiency which, in this particular case, means a lower cost of service to the vehicle owner.

I am inclined to doubt that the averaging of costs over the car that is taken care of and the car that is neglected is any worse from the owner's viewpoint than the fact that, on a time-and-material basis, the vehicle owner lucky enough to draw the fastest men in the service-station has an advantage over those less fortunate. In addition, the man that takes care of his vehicle will not be in for the work as often as the man who neglects his vehicle. As a matter of fact, the vehicle is designed in the first place on the basis of averages, plus the proper factor of safety. By this I mean that the vehicle is designed as nearly as possible to give good all-round results whether operated in the country or in the city, in the North or in the South, in the mountains or on the plains, by the hard driver or the easy one, all of which means that every owner sacrifices a little so that other owners with other operating conditions can get satisfactory results also. Obviously, if the vehicle were designed to fit only one set of conditions, somewhat better efficiency could be expected under those particular conditions; and the reverse would be true under other conditions unless several types of the same vehicle were produced. As I see it, the flat-price system of servicing handles costs along the same lines, that is, on broad general averages, is perfectly fair therefore, and not only is a more businesslike method of doing business, but also one that promotes efficiency throughout the relations between the service-station and the vehicle owner.

As I see it, Mr. Lord has covered the subject in excellent style; in fact, our procedure at the Packard Company has been very much along the lines Mr. Lord advocates. As an example of this, approximately 5 years ago we organized a separate division in our engineering department to handle service field-problems from an engineering viewpoint, and it is to service field-suggestions, properly analyzed and checked, that many of our current-model refinements have been due. Naturally, this department has been very close to the laying-down of new vehicles, to avoid the possibility of repeating previous service field-conditions. It is true that a great many service-field suggestions do not successfully stand investigation; this Mr. Lord refers to on the basis that the service-station may frequently cry "wolf." On the other hand, those that are substantiated more than offset the time lost on the other variety.

Along the same lines, the matter of accessibility of parts and units has been given very careful consideration, and a very definite advance has been made, largely as a result of our contact with the service field. Our technical service-department that handles the business negotiations with the service field tells me that the flat-rate system of service charges is now in effect in our service-stations and has given an excellent account of itself. In addition, it is stated by that department that the system has been improved recently by making the flat rate uniform throughout the Country according to three zones, and this appears to me to be very logical. In that same department service or repair tools are being developed from suggestions made by the factory organization, or from the service field and made available to the latter, and equal attention is being given to the proper ratio of vehicles to the quantity of service stock, so that each service station can carry the proper amount. In addition, the actual retail prices of the service parts are continually being scrutinized to keep them fair and proper. Naturally, the engineering department is assisting the technical service-department continually in all of these matters, and there is no question that the procedure is more than warranted.

A. J. SCAIFE:—The most important person to be considered is the customer, and any method that will bring the customer's viewpoint and his difficulties to the attention of the engineering staff should receive very careful consideration. It is undoubtedly true that every automobile plant of any consequence has a very elaborate method of tabulating complaints and recording parts failures in service, but it is difficult to get a large engineering organization stirred-up to the necessity of giving these complaints the consideration they should re-

ceive. One company that I know of has recently organized a department, the personnel of which has had considerable experience in the engineering end of the industry. The men in this department are spending their time in personal contact with dealers, fleet owners and individual customers, getting the first-hand information referred to by Mr. Lord. This information is brought into the factory, the individual making his report in person to the engineering committee. In this way, the most serious complaints are acted upon very quickly, and the other complaints receive consideration in proportion to their importance. This accomplishes two things; it brings the customer's viewpoint directly to the attention of the engineering staff and, in turn, it brings the engineering department of the factory directly into contact with the customer. The owner has many things to bring to the attention of the engineer, and the engineer also has many things to bring to the attention of the owner.

O. E. HUNT:—We thoroughly agree with Mr. Lord that the average factory engineering-organization is not closely enough in touch with the service problem and, as a result, has not the right attitude of mind toward it. We feel, however, that this condition is rapidly changing. The present highly competitive state of the industry has compelled all companies to appreciate that they are selling transportation service rather than a collection of design features, and that they will succeed just in proportion as they convince their public that they are giving comfortable and dependable transportation at less cost per mile than their competitors. This means that they cannot consider that the job is fully engineered until it has worn itself out in satisfactory service. This will certainly result in the service-man's getting more help from the factory organization than he was ever able to get heretofore. Economic pressure is sure to force the factory organization to help him.

R. E. FIELDER:—Service or maintenance of automotive equipment is a vital matter, particularly to the public-service corporations and other large companies rendering a definite daily service to the public at large.

A typical case might be described by taking the newest form of automotive service, that of mass transportation of passengers by motorbuses. In most cases a number of vehicles are used and are operating frequently for upward of 18 hr. per day, 365 days in the year. When using these vehicles, the public will insist that it arrive at its destination without any undue delay such as might be incurred by an involuntary stop due to a deficiency of mechanical maintenance. This state of affairs will necessitate that the operating company employ several experienced mechanics, and the time of work for these mechanics must be divided so that they cover the whole period of bus operation. It is obvious that, with this class of service, it will never be profitable to go to an independent garage or service-station at any time of the day or night and expect to get immediate attention for such buses while in service. If this were resorted to, there undoubtedly would be a tremendous loss of revenue due to buses lying idle or awaiting the convenience of another company to get them into operating condition.

In regard to the relations between operating and designing engineers, it is inconceivable that the designing engineer will ignore the experience and reports of his brother operating-engineer since, primarily, vehicles are produced to render a certain service and the efficiency of that service depends entirely upon the convenience to the mechanic in maintenance as well as manufacturing. The fundamental vehicle-requirements of the operating engineer are accessibility, simplicity, independent unit-construction, light-weight units that are easily handled, elimination of surplus refinements, fool-proof and accessible adjustments and lubrication devices that are accessible and have adequate storage capacity.

The ever-growing use of large fleets of automobiles operated under the control of individual companies has made it comparatively easy for the designers and the builders of the equipment operated to gain an easy and first-hand knowledge of the efficiency of their designs for the purpose for which they are used. The following is a system that has been successfully used:

(1) Every vehicle should be supplied daily with a card prepared so that the driver can write thereon all the faults and defects with which he has had experience during that day in the operation of his vehicle; also the mileage operated, the fuel and the oil consumed

(2) An experienced mechanical inspector should be allocated to the garage to receive the card from the driver of the vehicle, make an inspection of said vehicle in the presence of the driver and check his reports according to the cards

(3) Assuming the operation of a large number of vehicles, say 50 or more, the adjustment and repair work of those vehicles will be divided then among mechanics who are specializing in certain portions of the chassis, such as brakes, rear axles, change-speed and transmission gears, engines, gasoline tanks, and ignition and carburetion apparatus. Each of these various mechanics will have given to him a sheet on which will be marked the vehicle numbers that need attention with respect to the particular device in which he is specializing. Therefore, the information checked by the inspector from the driver's card will be transferred to the mechanic's sheet so that he can make the necessary adjustments and repairs during the interval that the vehicle is in the garage. The mechanic making the repairs will be responsible also for recording the correct information regarding the adjustment he makes or defect that he finds

(4) The mechanic's sheets, after being used by him, will be turned-in to the main office, where the reports from his sheets will be transferred to a master record-sheet of the particular vehicle. This record sheet may be known as the general-inspection sheet, the general inspection occurring approximately every 2000 miles, and will serve as a guide for the mechanics in charge of the overhauling of this vehicle, informing them of the particular defects and weaknesses that have occurred during its past 2000 miles of operation. This inspection sheet also should contain data pertaining to the miles the vehicle has operated and the amount of gasoline and oil consumed

(5) This overhaul sheet, having been completed by the mechanics or others in charge of repair and maintenance, will be sent to the engineering department, where an analysis can be made of the difficulties that occur during operation. The defects that predominate will point out to the engineers the weakness of the particular parts giving trouble, affording them an opportunity to redesign and improve such parts and thereby forming that necessary link between the operating department and the designing department

Concerning the relations between operating and production engineers, it is apparent that most of the requirements for operating engineers have been transmitted, heretofore, to the engineering department by the salesman who, more often than not, is nothing more than a pleasant fellow, with little practical knowledge of either

his customer's operation requirements or the necessities of design. On the other hand, we have the expert production-engineer who cares little or nothing about operating efficiency so long as he can produce an article for a certain price. This combination, no doubt, has worked out fairly well in the past, particularly for the individual passenger-car operator whose use of an automotive vehicle is frequently confined to summer evenings and week-end parties.

The automotive vehicle is today coming into its own and it seems safe to say that in the next few years it will be used in enormous quantities by large companies. If we stop to consider that a vehicle operating for upward of 50,000 miles per year can save 1 cent per mile in its mechanical maintenance, its fuel consumption and its wear-and-tear on tires, we will realize that this saving of $500 will offset very easily the saving in the manufacturing department of a few dollars, affecting only the initial cost of probably a $3,500 chassis. Assuming the average life of this vehicle to be 6 years, according to the foregoing calculation $3,000 can be saved, or practically the cost of the chassis.

I believe that the time has come when the operating engineer is the one to say which is the best type of vehicle to purchase, and this will be decided entirely upon operating and not initial cost; hence, the operating engineer's influence on the design of certain types of vehicle will be great.

With reference to efficiency in operating departments, one other matter that needs very careful attention by the designers of automotive equipment is that of supplying the maintenance department with adequate tools and facilities for the removal or the repair of these vehicles. This is imperative. Also, it is imperative that the operating engineer have such tools and equipment efficiently cared for.

J. W. LORD:—It seems to me that many of the engineers, though interested in service, have not been given the opportunity to get as close to it as they should be, and that the responsibility for this condition lies perhaps more with management than with the engineers. Though written reports carry definite information to an engineer, actual contact carries a much more vivid and lasting impression; therefore, steps should be taken to secure such vivid impression. A written statement that, in the course of an engineer's many duties, "goes in one eye and out the other," has been proved to be of no great value. If the management would realize this and also the value of having its engineers come into contact with the product in the field, I am sure it would see the value of providing ways and means and establishing a routine so that both the designing and the production engineers would have an opportunity to get much closer to service than is the general rule of the day.

E. W. SEAHOLM:—In my opinion, there is no more important engineering problem or one that deserves more attention from the designing engineer than the improvement of the product in relation to service. The points brought out in Mr. Lord's paper are well taken and admirably stated. In our organization we have followed the method outlined for several years. We are continually striving to reach the ultimate of perfection. Our technical department, which is the engineering branch of our service, maintains a very intimate touch with conditions of service by direct contact and through roadmen. All repairs, complaints and reports of parts replaced pass over the chief engineer's desk, and the tabulated data dealing with service problems serve as a valuable compass to our designers.

H. P. CROUZE:—I am glad to see that the engineers of the factory are beginning to feel that we service-men, who do all the squabbling with the owners, amount to something, after all. A number of them have asked us about some of our problems; strange to say, in the last 2 years they have listened to us.

W. J. DRETKE:—I am in accord with both Mr. Lord and Mr. Bachman. We have a field organization of seven service inspectors who visit plants manufacturing automobiles, trucks, tractors and other appliances in which our roller bearings are used. These field men bring to us all of the manufacturers' troubles. When necessary, they visit service-stations and bring their troubles in the field directly to the engineering and the service departments.

J. W. FLORIDA:—I attended recently one of the quarterly service meetings at our factory in Detroit. These meetings are held for the express purpose of bringing our service and maintenance problems before our engineers, who take the keenest interest in everything brought up. Those in attendance at these meetings comprise service managers of the various Packard distributors and dealers throughout the Country and factory officials and executives, as well as the factory field-men. With such splendid and progressive cooperation between the various district service-departments and the factory engineering-department, our service problems are kept at a minimum and service as a whole is held at a very high point of efficiency, thus effecting low maintenance costs to car-owners.

In regard to the so-called flat-price system, we call it standard-price repair-method and have adopted it nationally. We gave this system much careful thought and study to make sure of eliminating the "danger spots" that can easily enter it; these, we know, have been the cause of much unfavorable and just criticism against the flat-price system. With the aid of all its Class-A service-points throughout the Country, our factory was able to get a very broad view of what each repair operation costs and what the best methods are for doing them; so, after studying some 500 operations and striking an average of 10 similar operations from the various Class-A service-stations, some very gratifying results in getting prices to a lower level were obtained. Today, our standard-price repair-method is used by all our distributors and dealers. The system has for its main object the keeping of our customers' maintenance costs as low as possible consistent with the mileage and care their cars receive. In New York City, for instance, we have a higher labor cost than in many other sections where labor can be secured at cheaper rates, and it appears that in New York City we could not meet the low standard prices; but we have experienced no difficulty, because our volume of business and our facilities offset the handicap of the higher labor scale. I believe that the standard-price system has come to stay, especially when automobile companies go into it as thoroughly as ours has done and avoid the danger spots that existed in former so-called flat-price systems. Our standard-price system goes a long way toward helping our customers to keep their maintenance costs low.

L. T. HANFORD:—As a service-man, I will say that the subjects discussed indicate that, as engineers and service-men, we are on common ground in many ways. Certainly we both owe our jobs and livelihood to the car-owners, and we can pay our obligation to them by building and servicing the cars they buy and use in such a manner that the maintenance cost will be at a minimum to them. Personal contact will smooth out many of our

misunderstandings, just as we service-men find it does with our customers. Service-men should visit their factories regularly, armed with constructive criticism born of experience in making service repairs and inspections. Likewise, factory engineers, or their assistants, should go out into the field regularly and visit the service-men, to learn just what they are up against and see specimens of the repair jobs that they have to perform. We sometimes wonder whether, in design and production, the engineers give any thought to the servicing of the units or the parts employed.

DAVID BEECROFT:—With regard to the flat-rate system, there is considerable very good psychology connected with its use. I had a very good example of that several years ago, in Milwaukee, showing the good spirit and better understanding that it created among the dealers there. The Overland organization started the flat-rate system about $2\frac{1}{2}$ years ago in that city. The Nash organization in Milwaukee was not on the best of terms with the Willys-Overland Co., but they got together and talked over the flat-rate system, and a much better understanding developed between those organizations as a direct result. As an example of how it worked out, when the Nash organization took a Willys-Overland car in exchange, or vice versa, instead of attempting to do the repairing or overhauling in its own organization, it immediately passed the job over to the other company. The service managers of both organizations, and the managers also, admitted that, previous to the study they had given to this matter, they really did not trust each other to the extent of exchanging their overhauling work.

I think the effective psychology in the flat-rate system is that it puts both parties with their feet under the same table before the job starts; it means getting an understanding, presenting an analysis and, so far as the public is concerned, I think that is what it requires. The plan gets the public interested keenly in this matter when it sees the bills. The problem can be solved if it is analyzed at the start. The public is fully as willing to see the justice of the situation as the service department is to show the justice of it. If for no other reason than the fact that both parties get together and see the problem from perhaps a broader viewpoint, it is something that is very much to be desired. It is a confidence-building method.

RALPH ROGNON:—I believe we can obtain much benefit from this meeting. I believe an engineer lays plans and a service manager plans excuses; perhaps, regarding the latter, because we have not laid plans in the development of service. From the standpoint of the industry, we have simply been an adjusting department of the sales organization, in an industry that has had a quick growth.

There are two kinds of service; one is a warranty service and the other a maintenance service. When we lay definite plans and develop a maintenance service, we can take life easy, because we will not need to plan so many excuses. In analyzing the subject, there are three viewpoints. The first one is that of the owner. If we have a quota of 30,000 cars and the owners are paying a price for these cars without any consideration of a sane program of maintenance, the service department is suffering in the following way. Compared with the engineer of a locomotive or the operator of a printing press, who seeks efficiency from his machine as a craftsman, the average motorist simply seeks efficiency as a sportsman; instead of maintaining his car, he uses it for a period until trouble begins and then trades it in for a new one. In no other line of industry is the turnover so rapid or violent or senseless as it is in ours, and I think we are suffering as a result of it. If we could educate the owner into a sane program of maintenance, we would be doing a great good. Any other industry that has been successful has taken as its policy public need and demand.

Second, from a maintenance viewpoint, our own problems simmer right down to the production department. The engineer, after laying his plans, does not have to call several men together and tell them to build a truck without any definite plan; but in a service-station, we are called upon to send for a mechanic and say to him, "fix it." Third, I do not know just how to lay the proper plans, but I think much good can be done along the line of the standardization plans of the Society. What would we do if we did not have standardized bolts and nuts, and all the various standards the Society has established? In service, we must outline the plans of our men in production. It will mean the development of special tools, short-cuts and equipment which, I believe, the flat-rate system will develop. After all, we simply have a business situation to face in service, which involves a diagnosis of the trouble, the sale of the job at the contract price and prompt delivery.

CHARLES M. MANLY:—I agree with what has been said. The important feature is that the fundamentals back of this proposition are building up in the minds of the persons buying this service the idea of integrity and efficiency. Integrity is not worth much without efficiency and efficiency is not worth much without integrity; but if we can put across a combination of the two with the man who pays for this service, I think it makes very little difference whether it is a flat-rate system, a cost-plus system or some other system. The fundamental principle of the whole proposition lies in building up in the mind of the customer, whether he be a large or small customer, the feeling that there are both efficiency and integrity. I thoroughly agree with Mr. Rognon's remarks in regard to quotations on service work. When the service plans and work have been thoroughly laid out so that the man who is performing the work does it with as high a degree of efficiency as that at which the man at the factory is compelled to work to hold his job, service will be a real business proposition.

H. C. TRENT:—I am connected at present with both sales and service. When engineers and service-men get together, they are more or less inclined to call each other good fellows; nevertheless, frank statements and constructive criticism do us all much good. Mr. Lord's paper states that considerable help can be given to service-stations by standardizing on parts, so far as possible, and by discontinuing the constant changes in the design of such units as windshield frames, fenders, tire carriers, splash pans, and the like, which make it necessary to carry an extensive stock of these parts. At present, it is necessary for the owner who patronizes the parts department and the service-station, to know the serial number of his car, the model and the like, before he can be assured of getting the particular fender or splash pan used on his car. He may know the serial number and model, but it is very doubtful if he knows anything about the series, and other details. If he does not happen to have this information with him, or if he has sent someone to make the purchase for him, it necessitates his either going without the part or guessing at what is required; perhaps he finds out later that it is the wrong part, and this means that it must be returned for exchange. The result is a loss of time and money and a loss of the owner's confidence in the service-station. If we can eliminate this condition through the assistance of

the engineers, it will not only help service but also increase sales. I believe that closer direct contact between the engineers and the service-men in the field would be of great benefit.

AZEL AMES:—I think it safe to say that 10 years ago, the average owner of an automobile was not fit to be trusted, even in broad daylight, with an egg-beater, so far as his mechanical skill was concerned; but, in these days, when our children are talking about the merits of different types of radio apparatus that their parents do not understand, we may have some hope that the customer, the automobile owner, will have perhaps a greater realization of the properties of the transportation he is using and of the difficulties incident to its production, sale and maintenance.

The manufacturers, the dealers and the service-men are well organized. One reason they are organized is because it protects their individual interests; another reason is that it is easier to cooperate in this manner than to do so with a very great number of individuals. It may be that the manufacturer, the dealer and the service-man can work with the owner better if they work with the organized owner; certainly, those who are connected with the automotive industry know that for more than 20 years the American Automobile Association has represented the organized motorist, the customer, the man who furnished the automotive industry its bread and butter.

There is a glorious opportunity for the organized producer to work with the organized consumer. In behalf of the Metropolitan Division of the American Automobile Association I can say that, at least, we are on the job to work with the automotive industry; we are standing absolutely for the enforcement of the law and we do not ask for any special favors. We want a fair show for the motorist, in legislation, in taxation, in repair bills and in charges for fuel. We will work with the automotive industry, and we want it to work with us.

R. H. WOODHULL:—We also have been using the flat-rate system. If nothing else is accomplished, it brings an executive in close touch with his organization, regardless of the benefits it may have for the customer. Flat-rate costs properly computed show the actual performance in both speed and skill of the personnel. They show in dollars and cents how the individual is doing his part of the work. So far as the owner is concerned, often, when he has been promised his car for a certain day, the service-man telephones to say the job will not be finished until several days later. This puts the owner in a bad frame of mind. Then, if the charge is larger than he expected, there is bound to be dissatisfaction; but, if the owner leaves his car with a definite understanding as to the price he must pay and knows when he can expect it finished, he is well satisfied.

I often think the designing engineer has overlooked the fact that he may design something which is mechanically perfect but still not fool-proof. This is borne out by the fact that many models which proved satisfactory under factory road-tests are found to be sadly lacking when placed in the hands of the inexperienced owner. If the car has to be changed, it is because the man into whose hands it has been placed has not given it a chance; hence, a change has to be made to lubricate a certain part automatically or increase the strength of some part or assembly so it will not fail under abuse. Therefore, the closer the designing engineer gets to the ultimate user, the faster he will eliminate his troubles.

ETHELBERT FAVARY:—If I were a service-man, I would ask the engineer why it is that before it is possible to examine the crankshaft bearings of a certain truck it is necessary to take off the lower half of the crankcase. Moreover, before this can be done the body bolts must be loosened to get at the radiator bolts to remove them; then, one end of the engine must be lifted up with a hoist and, after some jockeying and shoving the engine over, it is possible to lift it up and get at the crankcase. In another case, if the front spring should happen to break, usually the crankcase breaks also as it would hit the front axle. In another design, when it becomes necessary to repair certain rear-axle parts, they are not accessible, although visible, and it is necessary to remove the entire rear-axle. There is no necessity for such inaccessibility, as the design can be rectified without sacrificing any advantages.

The engineers with the smaller companies complain that, when they are told to redesign the product, they are expected to do it in a few weeks; to do this and at the same time embody the improvements suggested in an efficient manner is often impossible. However, the company demands and insists on coming out with a new model by a certain time and hence does not allow sufficient time to the engineer for a first-class job.

I agree with Mr. Lord that there should be closer cooperation between the engineer and the service-man, but the engineer is of course responsible for the design and must use his judgment as to what is right and what is wrong.

S. M. WILLIAMS:—There is a very direct and definite obligation on the part of the selling departments to cooperate with the engineer. That can be brought about by a keener appreciation of the engineering problems and closer observation and a better understanding of the service problems.

E. A. MOREE:—It would be a source of great encouragement to most owners to know that the problems which face them on the mean end of a service bill are being considered in the broad-minded way in which they are being dealt with at this meeting. It would help us all if the purchasers of service could know that their service problems are receiving attention from men who approach them with the broad-gaged vision that has been evidenced here.

The service on automobiles has so improved within the last 10 years that it is not comparable with the service of 10 years ago. As a purchaser of service, when I get a bill with a flat charge on it that I can compare with a previous bill containing similar charges, I feel that I am buying something perfectly definite; while I may possibly be paying somewhat more than if charged the average price, I know that I am getting something for my money and that it is the same thing that I will get in the future if I happen to come in and have the same thing done. As the acting executive of the Automobile Merchants Association, this meeting has been an enlightenment and a gratification to me. When the message of this and future meetings gets to the purchasing public, as it is bound to do if the spirit of this gathering continues, it will reduce selling resistance and increase greatly the satisfaction that owners get from their cars.

E. J. RABIDOUX:—We find in general that we are getting fair cooperation between the engineers and the service-men, but I believe it can be improved greatly. We had a National Automobile Show in New York City recently that many automotive engineers attended. I have wondered how many of those engineers went to visit their service departments here in New York City, which probably has the largest service-department organization of any city in the United States. How many

of them had a talk with the service-men about the problem we are discussing?

I believe that we are not getting close enough to the service-man to learn what his problems are. We write letters and they are answered very courteously; but they do not seem to give what the service-man is trying to get, real help. These problems are serious; owners are demanding real service and, without the help of the engineer, we cannot give it to them.

A. J. Cook:—Many of the troubles between the engineers and the service department arise because the engineers do not get close enough to the problems. In many cases the trouble is in the details; usualy, the main parts do not cause trouble. However, adequate information is not passed along to the designing engineer; thus, there is a continual grouch in the service organization. Perhaps after 1 to 2 years, when the next design comes out, the trouble is eliminated.

If some of the engineers would put on overalls and get underneath the car as the "grease-balls" do, they would be in closer touch with the details that give trouble to the service-station. That is the only way they can get acquainted with them. In a large organization there are too many steps between the engineer and the man underneath, for the engineer to get close to those troubles. One of the best trucks on the market has a nut underneath it which, if one wants to get it off of the engine, requires considerable time. If the engineer could be made to take that nut off and put it on again repeatedly, he probably would alter the design.

Usually, there is only one man between me and the man who is doing the job; so, in many cases that man passes along the troubles that he finds on the jobs, and occasionally I get underneath the cars and work on those problems myself. If a knowledge of the troubles is not passed between the service-man and the engineer, the engineer cannot be blamed altogether for not knowing about them when there are so many steps between him and the man who is buying the car.

On the flat-rate system, no two jobs in the shop work out the same. In many cases, when a standard job is figured at a standard price, unforeseen things throw the calculations all out. Sometimes, jobs that are booked as the same job and that apparently should go through the same, involve something that one cannot calculate, such as a broken bolt or stud that is in a bad place to reach. In such an instance, it is difficult to explain to the customer why the charge is greater. Some customers will not listen to reason, and the service-station must stand the expense. If a customer can be given a general estimate on his repairs that states the lowest charge he can expect and the highest charge that will be made, that will work out satisfactorily. In working out that system of giving them the highest and the lowest prices they can expect, we canvassed 700 customers and received only 7 complaints. That is an actual working-out of the flat-rate system on the job.

H. I. Stengel:—With reference to average charges, I do not call them flat rates but prefer to call them fixed charges. I have some convincing statistics to present. Over a period of 6 months, during which time approximately 18,000 fixed-charge operations were completed, the total cost ran 8 per cent under the quoted price; this indicated very accurate estimating and especially strict supervision in the shops. The general idea that the owner who takes good care of his car suffers, or is overcharged, by the fixed-charge system, is due to a lack of knowledge regarding shop practice and to a lack of common sense. To illustrate by citing a common operation such as the relining of brakes, I find it makes no difference whether the owner has run the car 10,000 or 5000 miles, for, if the brake is worn sufficiently to require relining, the bands must be removed and the rivets cut off with a chisel and that requires a given amount of time and material. The same principle can be applied to engine bearings. Suppose one man takes exceptionally good care of his car and another man neglects his car. The latter must have the bearings taken up more frequently than the former. As Mr. Lord has said, if tools and pullers designed for the work are available, the shop mechanic can perform the needed operation consistently, regardless of the condition in which he may find the parts. It makes no difference whether the shackle bearing or bolt comes out easily or not, once a good puller is applied to it. A frozen shackle comes out very easily.

There is only one way in which a fixed-charge system of prices can be carried on successfully in a service repair-shop; it is by organizing the shop and the cost-accounting department properly, so that the cost can be kept accurately and consistently. By organizing the shop I mean the specializing of the work of the shop mechanics for, by specializing alone, can one expect a mechanic to become efficient. Tool equipment is also one of the very important factors, as poor tools not only hold-up the work but demoralize the mechanics. It is believed that if all owners whose cars have been serviced in our shops were requested to state their preference, not more than 5 per cent would ask for a return to the old system.

Chairman Lee J. Eastman:—In the old days, the engineer knew it all. If a truck or a car broke-down and the engineering department was told about it, the reply would be, "That cannot happen. From an engineering standpoint, the machine is built right; it cannot break." However, among the very hopeful signs is the fact that both the engineers and the service-men admit that they do not know it all. That is a sign they are both learning.

One of the other encouraging features is that the engineering departments of our various factories are becoming more and more merchandising engineers. In the old days, it was customary to build a model without consulting the distributing organization and to send it out and say, "There it is! Sell it!" It made no difference whether the model met the public demand or whether the resistance in selling it was extremely keen, the engineer felt it was right and what the public ought to have. It was difficult indeed to sell some of those models.

We see a very strong tendency now for the engineering department to consult more and more with both the service and the distributing organizations to ascertain whether, if it should build a certain type of model with certain features, there would be a ready sale for it.

One of the main factors that exists to the detriment of service consists of broken promises. If I am told that I will have my car repaired and ready at a certain time, nothing will exasperate me more than to receive a telephone message that I cannot have the car until several days later. Our service departments should strive to be sure that they do not make promises they cannot keep.

Another thing regarding which our service departments are extremely negligent is the matter of "selling" the service that we have. I am pretty well sold in favor of the flat-rate system, but I think we still have to sell it to the public; and, more than selling the flat-rate system to the public, we should sell what is back of the flat rate and show why the flat-rate system is better for the customer, the efficiency that has been brought into our service department that has enabled us to put out a flat-rate that is fair, and the like.

Thickness and Resistance of Oil-Films in High-Speed Bearings[1]

By DR. GERALD STONEY, R. O. BOSWALL AND J. MASSEY

Illustrated with DRAWINGS

ALTHOUGH the problem of efficient lubrication has been made the subject of considerable investigation during the course of the last few years, it is a noticeable fact that while the theoretical side of the work has received extensive development, notably from Osborne Reynolds, Sommerfield, Michell and Martin, the experimental side, represented by the researches of Tower, Stribeck and Lasche among others, has been confined entirely to measurements of pressure distribution, temperature changes and shear or frictional resistance, no direct attempt having been made apparently to determine experimentally the actual thickness of an oil film or to discover in what way this thickness changes with variations in the load, the rubbing speed and the viscosity. With the express object of filling this gap in what must of necessity be regarded as a subject of increasing practical importance, owing to the recent rapid developments in turbine construction, an experimental investigation of an essentially preliminary character has been carried out during the past year at the College of Technology, Manchester.

The apparatus employed was designed specially for the purpose, and the measurements of the oil-film thickness

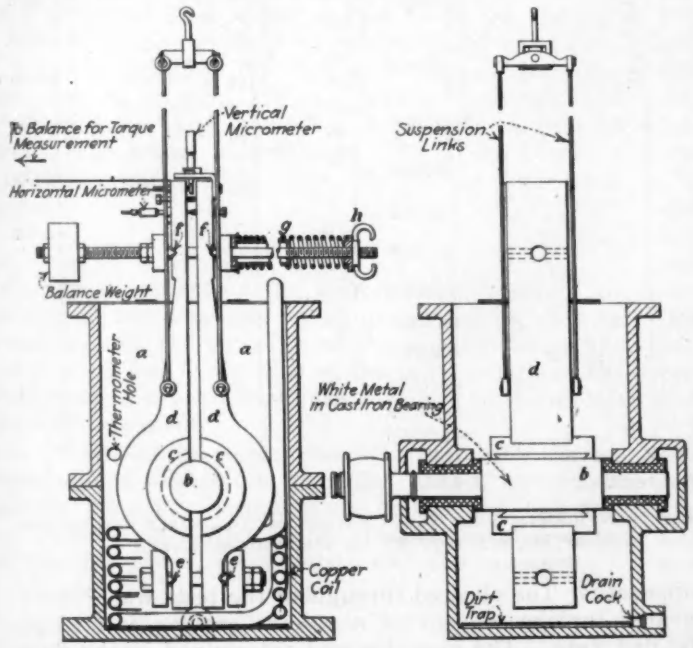


FIG. 1—FRONT AND SIDE ELEVATIONS OF A MACHINE DEVELOPED IN ENGLAND TO MEASURE THE THICKNESS AND RESISTANCE OF OIL-FILMS IN HIGH-SPEED BEARINGS

and the shear or frictional resistance that have been obtained from it up to the present appear to be of sufficient interest to justify their publication. The apparatus, which is shown in Fig. 1, consists essentially of a cast-iron casing *a*, provided with two gun metal bear-

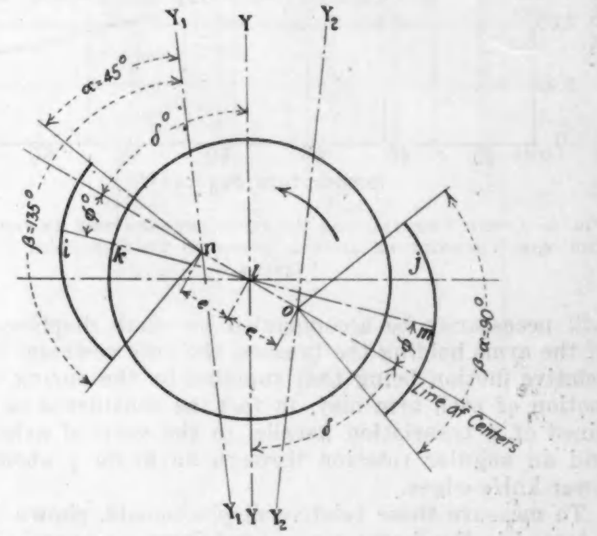


FIG. 2—DIAGRAM ILLUSTRATING THE PRINCIPLE UPON WHICH THE MACHINE OPERATES

ings in which runs the mild steel journal *b*, speeds of from 2500 to 6000 r.p.m. being obtained by a belt drive from a small electric motor. The central portion of the journal, 2½ in. in diameter, is embraced by two opposing symmetrically-shaped white metal bearings *cc*, each 4 in. long and carefully scraped to fit the journal as exactly as possible over an arc of contact of 90 deg. These bearings are secured to two arms *dd*, which are held together by two independent links provided with knife-edge attachments. The lower pair of these knife-edges *ee*, are maintained at a fixed distance apart, while the upper pair *ff* are relatively movable, being controlled by the calibrated spring *g*, which can be compressed by the wing nut *h* so that any desired pressure can be exerted by the bearings on the journal, the lower knife-edges acting as a fulcrum. The weight of the arms and their various fittings is counterbalanced by a four-rod suspension to relieve the journal of all vertical pressure, the position of these points of suspension on the arms being chosen so as to maintain just sufficient rotational stability about the journal axis to keep the arms in their normal vertical position, while not interfering with possible displacement of the arms relative to one another.

The casing is filled with oil to a level of about 3 in. above the top of the journal, a copper water circulation coil being inserted in the lower half of the casing to facilitate temperature regulation. The method of operation of the apparatus is briefly as follows: Referring to Fig. 2 and assuming that the two white metal bearings *i* and *j*, are initially in contact with the journal and under the influence of pressure due to the spring, a rotation of the journal in the direction indicated will result in a wedge-shaped film of oil being introduced between each brass and the journal, the thickness of this film being dependent upon the pressure, the rubbing speed and the viscosity of the oil. The formation of this film

[1] Reprinted from *Engineering* (London).

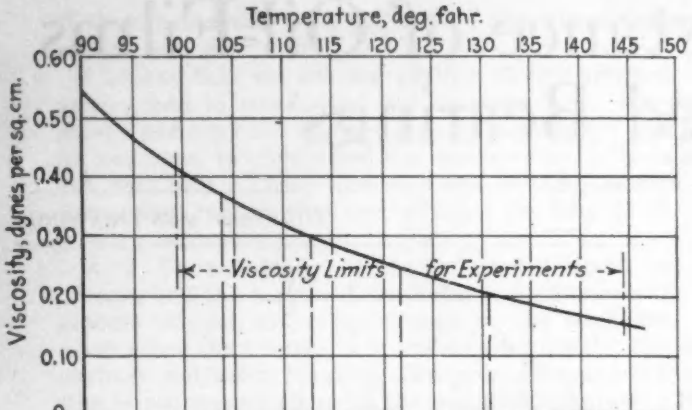


FIG. 3—CURVE SHOWING THE RELATION BETWEEN THE TEMPERATURE AND THE VISCOSITY OF AN OIL INTENDED TO LUBRICATE TURBINE GEARS

will necessarily be accompanied by small displacements of the arms holding the brasses, the only restraint to the relative motion being that supplied by the spring. The motion of each arm may, in fact, be considered as combined of a translation parallel to the vertical axis Y Y and an angular rotation through an angle γ about the lower knife-edges.

To measure these relative displacements, shown much enlarged in the figure, two micrometers, one vertical and the other horizontal are fitted at the end of the arms, the measurements thus obtained enabling the actual displacement of the brasses relative to the journal and the thickness of the film to be calculated. The shear or frictional resistance was determined by the measurement of the horizontal force required at the end of the arms to counteract the turning effect about the journal axis

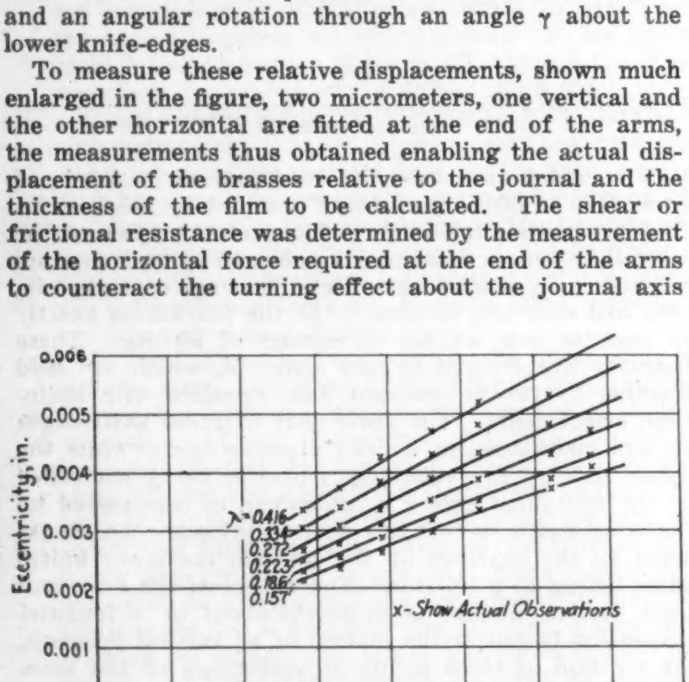


FIG. 4—CURVES GIVING THE RESULTS OBTAINED

and maintain the arms in their normal vertical position.

It will be seen that if Φ represents the angle between any radius $k\ l\ m$ and the lines joining the center of the journal l to the displaced centers n and o of the brasses, the thickness of the film at this point will be given by the formula

$$t = e \cos \Phi$$

where e is the eccentricity or distance between the center of the journal and the center of the brass. Also, if α is the angle between the line of centers and the vertical axis $Y\ Y$, the thickness of the oil film at the inlet and the outlet will be given by the formulas

$$t_1 = e \cos (\alpha - \delta)$$
$$t_0 = e \cos (\beta - \delta)$$

The values for e and α can be calculated from the micrometer measurements and the known dimensions of the

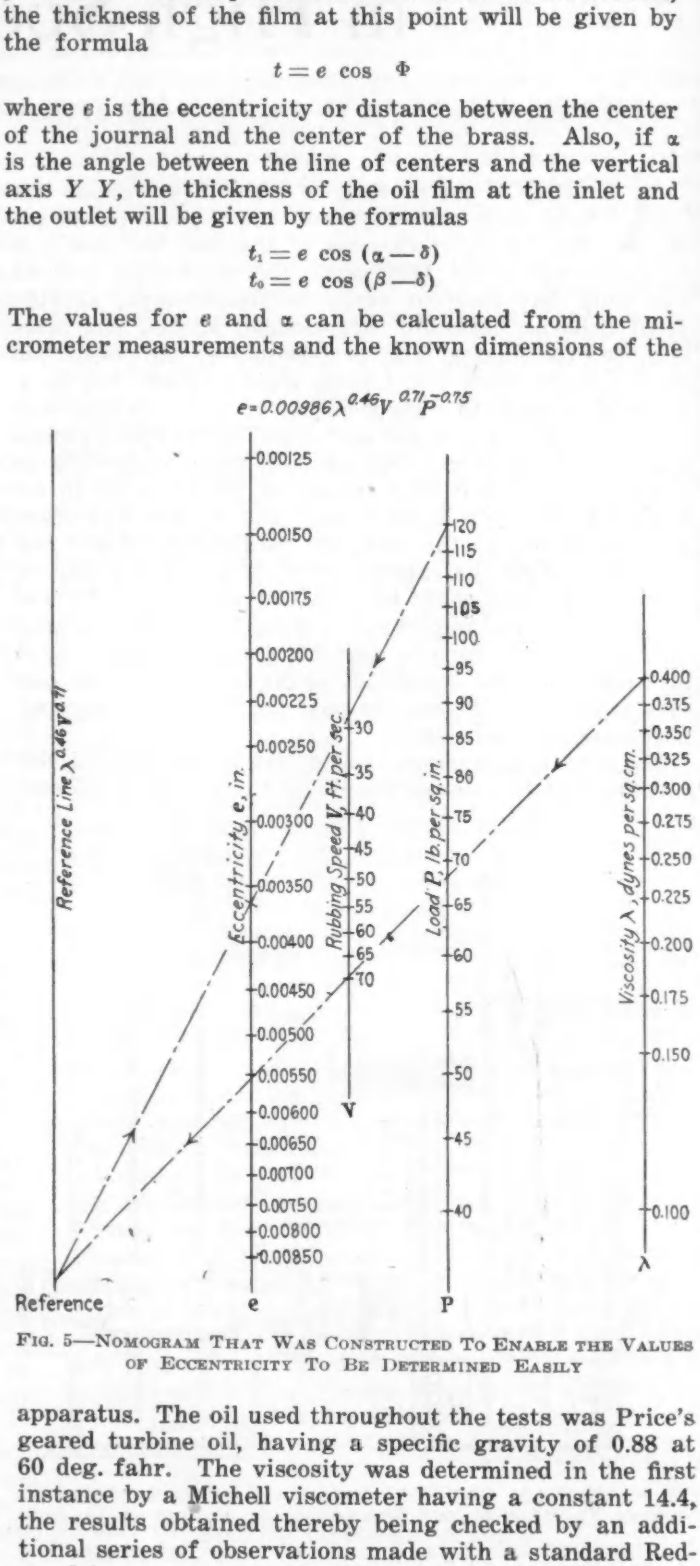


FIG. 5—NOMOGRAM THAT WAS CONSTRUCTED TO ENABLE THE VALUES OF ECCENTRICITY TO BE DETERMINED EASILY

apparatus. The oil used throughout the tests was Price's geared turbine oil, having a specific gravity of 0.88 at 60 deg. fahr. The viscosity was determined in the first instance by a Michell viscometer having a constant 14.4, the results obtained thereby being checked by an additional series of observations made with a standard Redwood instrument, a calibration formula being applied to reduce the times of outflow to absolute units of viscosity or dynes per square centimeter, as given directly by the Michell instrument. The agreement between the two methods was very satisfactory and the viscosity-temperature curve is shown in Fig. 3, the relationship between the two variables over the temperature range

used being expressed to a close approximation by the formula:

$$\lambda = 1980 \div (T - 32)^2$$

where

λ = viscosity in dynes per square centimeter
T = temperature in degrees fahrenheit

The procedure adopted when taking observations was briefly as follows: The oil, brought to the required temperature by the rotation of the journal with the spring set for some convenient load, was maintained at this temperature by regulating the flow of cooling water through the coil until the whole apparatus had become correspondingly warmed up. The journal was then stopped and the spring correctly adjusted to give the desired test load on the brasses. Initial zero readings having been taken, the journal was restarted and measurements made for a series of gradually increased speeds, at the end of which the journal was stopped and zero readings again taken as a check.

An analysis of the complete set of results indicates that within the limits of the experiments which were from 39.5 to 117.5 lb. per sq. in. for load; 28 to 67 ft. per sec. for rubbing speed; and 0.416 to 0.157 centimeter-gram-second units for viscosity, the eccentricity e and the intensity of shear, ρ, or its equivalent $\mu\rho$, may be expressed to a very close degree of approximation by the formulas

$e = 0.00986 \; [(\lambda^{0.46} V^{0.71}) \div P^{0.75}]$ inches
$\rho = 0.0370 \; \lambda^{0.420} . V^{0.475} . P^{0.375}$ pounds per square inch

where

λ = the viscosity in dynes per square centimeter
V = the rubbing speed in feet per second
P = the intensity of pressure on the brasses in pounds per square inch

The intensities of pressure and shear are reckoned on the full projected area of the journal, 10 sq. in. In putting forward these formulas we reserve, until more complete data are available, the divising of rational formulas which shall be applicable to all similar bearings, and they are put forward merely as a compact method of recording the actual observations. These formulas do not compare unfavorably with the purely theoretical formulas

$$e = c\sqrt{(\lambda V \div P)}$$
$$\rho = K\sqrt{(\lambda V P)}$$

the discrepancy affecting the indices being possibly attributable to the combined effect of the lateral flow or side leakage and the variation of the viscosity along the arc of contact due to the rise of the temperature of the oil film, both of which factors are neglected in the simple theoretical treatment.

It is important to notice, however, that both the experimental and theoretical formulas are in agreement respecting the dependence of shear on the load, this fact being in direct opposition to the usually accepted statement that the shear is independent of the pressure.

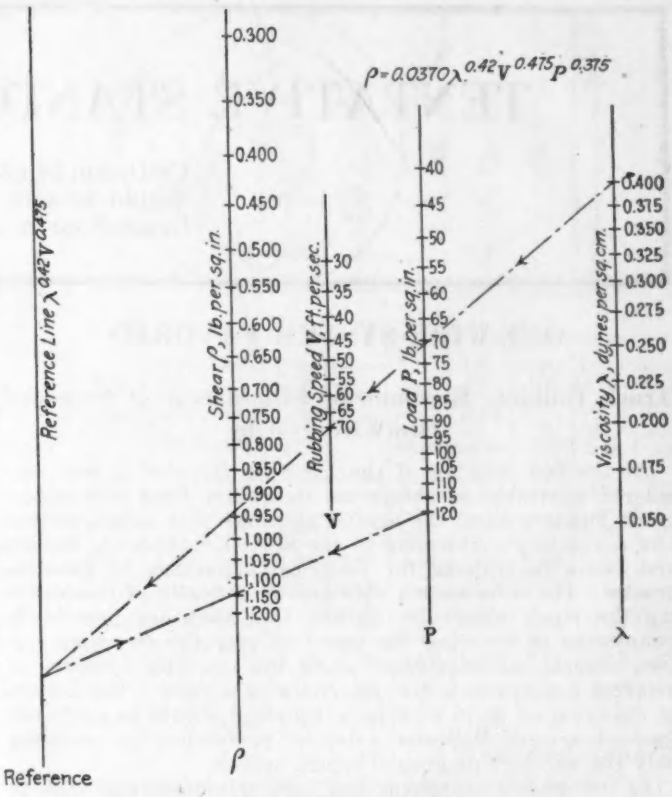


FIG. 6—VALUES OF SHEAR CAN BE DETERMINED READILY BY THE USE OF THIS NOMOGRAM

A further point of interest is that the position for the line of centers with reference to the vertical axis Y Y appears to be independent of the load and speed and only slightly dependent upon the viscosity, the angle only altering 3 deg., from 66 to 63 deg., as the viscosity changes from 0.416 to 0.157 dynes per sq. cm. The ratio between the inlet and outlet thickness of the oil film shows a corresponding change from 2.6 to 3.0.

The results obtained for a total load of 592 lb., corresponding to 59.2 lb. per sq. in. on the bearing, are shown in Fig. 4, the curves being drawn to correspond with the experimental formulas given above. Similar sets of curves were obtained for the four other loads that were tested. In addition two nomograms, Figs. 5 and 6, have been constructed for the easy determination of values for eccentricity and shear for any combination of λ, P, and V.

The experimental work described is at the moment being extended further to investigate the effects of varying the arc of contact, the length of the bearing and the diameter of the journal. It is hoped that these additional tests will help to throw more light on what is unquestionably a difficult and complicated subject.

EFFECT OF OXYGEN UPON FORGING PROPERTIES

A SHORT series of iron-sulphur-manganese alloys has been prepared by melting under air at the Bureau of Standards, for comparison with a portion of a similar series prepared in the Arsem vacuum furnace, to determine whether the presence of oxygen in the alloy influences the sulphur limit and the manganese-sulphur ratio for successful forging. It has been necessary to develop a new type of refractory crucible for use in preparing the carbon alloys of the vacuum-fused series of this investigation. Manganese crucibles are not desirable on account of the slagging out of the sulphur. Zirconium silicate crucibles served satisfactorily for the preparation of the iron-sulphur and iron-sulphur-manganese alloys, but with the addition of carbon, the alloys are contaminated by silicon. Tests are now in progress to determine the suitability of a crucible the chief constituent of which is zirconium oxide.

TENTATIVE STANDARDIZATION WORK

Criticism of all tentative reports should be sent to the Standards Committee in care of the Society

ONE-WIRE SYSTEM FAVORED

Truck Builders Recommend Elimination of Standard Two-Wire System

At the last meeting of the Lighting Division it was considered advisable to obtain an indication from the motor-truck builders as to the service obtained with bases, sockets and connectors conforming to the S. A. E. standards for one and two-wire systems for electrical apparatus on gasoline trucks. The information obtained as a result of circularizing the truck companies showed that they are practically unanimous in favoring the one-wire over the two-wire system, several manufacturers using the two-wire systems indicating a preference for the one-wire system. The replies to the question as to whether a standard should be continued for both systems indicated a decided preference for retaining only the one-wire or ground-return system.

As the present standards had been criticized from time to time to the effect that they do not stand-up under severe truck service, information was requested on what troubles had been experienced. The principal difficulties reported were poor workmanship and poor ground connections. One or two manufacturers believed that the present standard sockets were too small for motor-truck applications.

Through the American Petroleum Institute comments were received from the Advisory Committee on Fire Prevention and Protection to Life and Property as to the use of the one-wire and two-wire systems for gasoline tank trucks which showed the refiners are evenly divided as to which system should be used. The argument was advanced by several that the two-wire system gives little more protection from short-circuits than the one-wire system on the basis that if one wire becomes grounded there is no indication of such a ground, with the result that the system becomes practically a one-wire system, another ground on the opposite side of the circuit already grounded causing a short-circuit.

SIX-POINT CARBON RANGE DISCUSSED

Iron and Steel Division Decides Change in 10-Point Range Is Not Desirable

The suggestion that the 10-point carbon range in the present Iron and Steel Specifications should be changed as described in full in the May issue of THE JOURNAL was discussed at great length at the May meeting of the Iron and Steel Division, but no decision was made other than to lay the subject on the table in view of the absence of proponents of the closer carbon and alloy-ranges. General discussion indicated that whereas the narrowing of the carbon range was a desirable step from a metallurgical standpoint and one that could be practically employed by those manufacturers purchasing in such large quantities as to permit selection at the mill, in the case of the average steel purchaser who used only a limited range of compositions, the application of such closer limits might introduce serious purchasing and delivery troubles. It is expected that the subject will be discussed in further detail at subsequent meetings of the Division.

The subject of high-chromium steel was discussed at the last meeting, the subject having been assigned to the Division by the Council. In order to facilitate the work of the Division, B. M. DeLong, of the Carpenter Steel Co.; H. J. Stagg, of the Halcomb Steel Co., and R. H. Davis, of the Sterling Steel Co., were appointed a Subdivision to prepare a preliminary report.

HIGH NUTS AN AID IN SERVICING

Nuts Higher Than S. A. E. Standard Developed to Increase Accessibility

The present S. A. E. Standard plain and castle nuts are designed so that the height permits sufficient thread to develop a shearing strength equivalent to the tensile-strength of the bolt. It has been found, however, that when the standard nuts are used in more or less inaccessible places it is extremely difficult to obtain sufficient hold with a wrench to permit easy removal or to obtain the proper tightness.

A type of nut has therefore been developed by engine builders that has a height considerably greater than that of the standard nut. Experience has shown that the use of these special nuts, sometimes called "high nuts," are of considerable value from a servicing point of view and facilitate assembly.

The advisability of establishing a definite standard for such nuts has been referred to the Screw-Threads Division. To determine to what extent these special nuts are used in practice, the Standards Department has circularized manufacturers and users for information as to present practice.

STORAGE-BATTERY REVISIONS PROPOSED

Division Acts on Automotive Simplified Practice Committee's Recommendations

At a meeting of the Storage-Battery Division held on May 17 recommendations were received from the Automotive Simplified Practice Committee as a result of a survey made of the storage-battery situation in the automotive industry. The survey, which indicated that over 85 per cent of the batteries used conform to the present S. A. E. Standard for storage-battery dimensions, was made in pursuance of the work of reviewing the extent of use of the more important automotive standards that affect replacements, in an effort to further their adoption in practice.

The Automotive Simplified Practice Committee recommended that the Storage-Battery Division establish definite storage-battery compartment lengths that would be satisfactory for the standard storage-battery sizes, the length being selected so that batteries of larger capacity than the original equipment might be used if desired; that the Storage-Battery Division review the present S. A. E. Standard to determine if any revisions are desirable; that definite dimensions for the hold-down device be included in the existing standard; that the Division circularize all automobile companies to determine if they are using the storage-battery compartment dimensions to be recommended and, if not, if it will be possible for them to use such dimensions in future production.

As the result of these recommendations, the Division pro-

posed the following revisions in the existing S. A. E. Standard for Storage-Batteries, p. B23 of the S. A. E. HANDBOOK:

Storage-battery compartment lengths shall be 11, 12⅝ and 13½ in.

The depth of storage-battery compartments measured from the bottom of the compartment, not from the top of the wood strips in the compartment, shall be 10⅝ in.

Hold-down devices shall be attached at the top of each end of the battery case, not at the top of the handles.

The hole for the battery hold-down rod shall be ⅝ in. in diameter, located on the center-line of the battery and 3/16 in. from the end of the battery case. The maximum overall lengthwise dimension of the hold-down device shall be 17/32 in.

Battery sizes Nos. 4 and 9, which are no longer used as original equipment, shall be eliminated.

MOLYBDENUM STEELS

The subject of standardization of molybdenum steel, assigned to the Iron and Steel Division by the Council, was discussed at the last meeting of the Division. In order that information might be obtained as to present practice and tentative specifications for chemical compositions formulated, the subject was referred to the Subdivision on Chromium and Chromium-Vanadium Steel, of which M. H. Schmid, of the United Alloy Steel Corporation, is chairman.

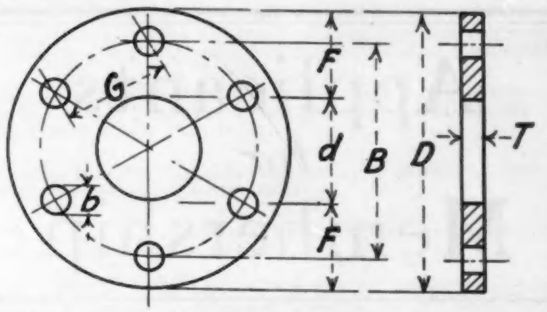
FLEXIBLE-DISC STANDARD PROPOSED

Tentative Subdivision Report on Universal-Joint Flexible Discs Circularized

At the present time an unnecessarily large number of universal-joint flexible-discs are in general use, owing to the unguided development of this unit. This condition naturally worked an undue hardship upon the flexible-disc manufacturers, as well as in servicing. Appreciating these conditions, the Parts and Fittings Division appointed a Subdivision, consisting of C. W. Spicer, of the Spicer Mfg. Corporation, and E. W. Templin, of the Goodyear Tire & Rubber Co., to review the situation and submit a preliminary recommendation as to what flexible-disc dimensions should be included in an S. A. E. Standard, provided it should be desirable to formulate one.

As a result of considerable study of present practice and the fundamental conditions under which universal-joint flexible discs operate, the Subdivision submitted a series of nine sizes of flexible disc and corresponding torque ratings, the sizes being in accordance with the most desirable engineering practice. The preliminary recommendation is given in the accompanying table.

In submitting the report, the Subdivision states that the maximum and average torque to be transmitted through the disc should not exceed that specified if the most efficient service is to be obtained. The maximum torque rating is



Nominal Size	Outside Diameter D ±0.030	Inside Diameter d ±0.030	Bolt-Circle Diameter[1] B ±0.015	F	G ±0.010	Bolt-Hole Diameter b +0.000 −0.010	Thickness T[1] +0.030 −0.010	Torque Ratings, Lb-In. Per Disc: Maximum	Average
6 x¼	6.000	2.250	4.625	1.875	2.3125	0.500	0.250	910	225
6½x¼	6.500	2.375	5.000	2.000	2.500	0.500	0.250	1,060	260
6½x$\frac{5}{16}$	6.500	2.375	5.000	2.000	2.500	0.500	0.313	1,320	330
7 x$\frac{5}{16}$	7.000	2.625	5.250	2.125	2.625	0.500	0.313	1,520	380
7½x$\frac{5}{16}$	7.500	2.750	5.625	2.375	2.813	0.500	0.313	1,740	430
7½x⅜	7.500	2.750	5.625	2.375	2.813	0.500	0.375	2,080	520
8 x⅜	8.000	3.000	6.000	2.500	3.000	0.625	0.375	2,360	590
8½x⅜	8.500	3.000	6.250	2.750	3.125	0.625	0.375	2,650	660
9 x⅜	9.000	3.250	6.500	2.875	3.250	0.625	0.375	2,950	740

[1]The thickness of a single disc shall not vary by more than 0.020 in.

based on an allowable stress of 325 lb. per sq. in. of cross-section of the disc, and the average torque rating is based on a stress of 80 lb. per sq. in. The ratings are intended for normal conditions of speed and alignment, it being stated that in general discs will not give good service in installations where the angle between the shafts exceeds 7 deg.

At the request of the Subdivision the Standards Department submitted copies of the preliminary report to manufacturers of flexible discs and users of flexible-disc universal-joints, requesting definite comments on the following points:

(1) The desirability of the standardization proposed.

(2) Whether the list of suggested sizes would meet all probable requirements of the industry.

(3) Objections to any dimensions or sizes specified, together with the definite recommendations as to substitutions.

(4) Objections to any of the torque ratings proposed, together with definite recommendations as to substitutions.

The Subdivision will review the preliminary report in the light of all comments received and the report, revised if found desirable, will then be submitted to the members of the Parts and Fittings Division in accordance with the regular standardization procedure.

OBITUARY

WILLIAM W. DEAN, an electrical engineer for the United States Cartridge Co., Lowell, Mass., died of heart failure on May 3, 1923, while in New York City on a business trip, aged 59 years. He was born July 8, 1863, at Fairfield, Iowa.

Following his general education he was an engineer for the Bell Telephone Co., St. Louis, from 1882 to 1897, and for the American Telephone & Telegraph Co., Boston, from 1897 to 1898. He was chief engineer of the Kellogg Switchboard & Supply Co., Chicago, from 1898 to 1900, and experimental engineer for the Western Electric Co., Chicago, from 1900 to 1904. Becoming president and chief engineer of the Dean Electric Co., Elyria, Ohio, in 1904, he continued this connection until 1911 and then was vice-president and chief engineer of the Dean Auto Devices Co., Chicago, until 1914.

As a consulting engineer, he was connected with the Stromberg Carlson Telephone Mfg. Co., Rochester, N. Y., from 1914 to 1915, and with the Splitdorf Electrical Co., Newark, N. J., following 1915, where he designed and developed inventions pertaining to electrical equipment for automobiles. Subsequently, his activities continued along consulting electrical engineering lines in Stamford, Conn.; Newark, N. J., and Chicago, until he associated himself with the United States Cartridge Co. Throughout his career, he specialized in electrical invention and design. He was elected to Member grade in the Society, Jan. 10, 1917.

Applicants *for* Membership

The applications for membership received between May 15 and June 15, 1923, are given below. The members of **the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.**

AFFLECK, EDWARD T., general manager, Dé Jon Electric Corporation, *Poughkeepsie, N. Y.*

BACHMAN, GRAYDON A., student, University of Minnesota, *Minneapolis.*

BOVEY, THOMAS, president and chief engineer, Bovey Automobile Heater Co., *Chicago.*

BROGAN, G. W., advertising manager, Black & Decker Mfg. Co., *Baltimore.*

BRONSON, ADELBERT E., secretary, Dill Mfg. Co., *Cleveland.*

BRYANT, WILFRED ROBERT, engineer, Hole & Bryant, *Taunton, Somerset, England.*

CARLOS, MENELEO G., student, Cornell University, *Ithaca, N. Y.*

CARR, HARRY R., inspector and tester of electrical trucks, Ward Motor Vehicle Co., *Mount Vernon, N. Y.*

CHASE, L. C. & Co., 81 Franklin Street, *Boston.*

CISLER, WALKER L., cadet engineer, Public Service Electric Co., *Newark, N. J.*

CONRADI, L. C., chief chemist, Spicer Mfg. Corporation, *South Plainfield, N. J.*

COOK, ROY J., Eastern manager of sales, Westinghouse Union Battery Co., *Swissvale, Pa.*

CRESCENT, TOOL Co., *Jamestown, N. Y.*

DEMEILLERS, RAOUL A., tool supervisor, Gould & Eberhardt, *Newark, N. J.*

EIGE, ELMER H., student, University of Minnesota, *Minneapolis.*

FAIRER, ALFRED JOHN, managing director, Central Motor Hiring Co., Ltd., *London, England.*

FALGE, ROBERT N., engineering department, National Lamp Works of the General Electric Co., *East Cleveland, Ohio.*

FINCH, O. F., chief draftsman, Duesenberg Automobile & Motors Co., *Indianapolis.*

FUKUI, SHIRO, 84 Yokozicho Ushikomeku,*Tokyo, Japan.*

GELZER, J. A., sales engineer, Wagner Electric Corporation, *St. Louis.*

GILLIES, GORDON C., manager of tachometer division, Elgin National Watch Co., *Chicago.*

GRABNER, JOHN, draftsman, Continental Motors Corporation, *Detroit.*

GRANT, JOHN M., assistant service manager, White Co., *Long Island City, N. Y.*

HARDING, JOHN V., sales manager, Bovey Automobile Heater Co., *Chicago.*

HOOKER, JOHN C., service investigator, Bronx Stratton-Bliss Co., *New York City.*

JENKS, CLIFTON E., material engineer, Glenn L. Martin Co., *Cleveland.*

JUERGENS, E. C., chief engineer, Old Reliable Motor Truck Corporation, *Chicago.*

KAHRS, OTTO, engineer, *Christiania, Norway.*

KERR, STEPHEN LESTER, student, University of Utah, *Salt Lake City, Utah.*

KLEMENTS, JOE M., detailer, Cleveland Automobile Co., *Cleveland.*

LAKE, HARRY W., inspector of aeronautical engines, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

LAMB, JAMES CHARLES, proprietor, J. C. Lamb & Co., *Dundee, Scotland.*

MCCORMACK, DENIS, assistant sales manager and automobile engineer, Western Motor Co., *Bristol, England.*

MAYES, W. A., chief engineer, Martin-Parry Corporation, *York, Pa.*

MULLER, JOSEPH J., designing engineer, Belmont Motors Corporation, *Lewiston, Pa.*

NELSON, REGINALD, chief mechanic, Borden Farm Products Co., *Brooklyn, N. Y.*

NEWTON, F. I., secretary, G. & O. Mfg. Co., *New Haven, Conn.*

OFENSEND, CHASE F., mechanical engineer, Miller Rubber Co., *Akron, Ohio.*

PANEK, EMIL, engineer, Globe Machine & Stamping Co., *Cleveland.*

PETERSEN, EYVIND, die-casting engineer, Fairbanks, Morse & Co., *Beloit, Wis.*

POTTER, ERIC, consulting engineer, Commerce Chambers, Parliament Street, *Nottingham, England.*

RADFORD, W. H., vice-president, Balboa Motor Corporation, *Detroit.*

SATTERTHWAITE, GEORGE, manager of steel works, Henry Disston & Sons, *Tacony, Philadelphia.*

SHIELD, JOHN, assistant engineer, Northern Electric Co., *Montreal, Que., Canada.*

SMITH, J. LITSEY, manager of lubricating department, Midland Refining Co., *El Dorado, Kan.*

STARCK, W. A., engineer, Badger Mfg. Co., *Milwaukee.*

STEIN, CHARLES M., director, Société des Automobiles, *Paris, France.*

STROM, GEORGE A., vice-president, U. S. Ball Bearing Mfg. Co., *Chicago.*

STYRI, HAAKON, chief, S. K. F. Research Laboratory, *Philadelphia.*

SULLIVAN, ALAN P., chief engineer, Stackpole Carbon Co., *St. Marys, Pa.*

THOMAS, MICHAEL, experimental engineer, Stromberg Motor Devices Co., *Chicago.*

VOGEL, RALPH EMERSON, student, University of Illinois, *Urbana, Ill.*

WALL, MAX, motor engineer, Max Wall & Co., Ltd., *Wellington, New Zealand.*

WALTER, EDFORD MILTON, mechanical engineer, General Motors Research Corporation, *Dayton, Ohio.*

WERRA, JULIUS W., assistant engineer, Werra Aluminum Foundry Co., *Waukesha, Wis.*

WERTZHEISER, JOSEPH, factory manager, Lawrance Aero Engine Corporation, *New York City.*

WINDLE, E. HOWELL, student, Ohio State University, *Columbus, Ohio.*

WOOD, ALBERT HENRY, automobile engineer, G. C. Gooderham Co., *Toronto, Ont., Canada.*

WOODWARD, L. A., president, Weldless Tube Co., *Wooster, Ohio.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between May 10 and June 9, 1923. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ADAMS, JAMES R. (M) superintendent of research department and plant metallurgist, Nicetown plant, Midvale Steel & Ordnance Co., Philadelphia, (mail) *Hatboro, Pa.*

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BENÉT, LAURENCE V. (M) vice-president, Societe Anonyme des Anciens Establissements Hotchkiss & Cie, St. Denis, Seine, France, (mail) 22 Rue Caumartin, *Paris, France.*

BLACKMORE, CHARLES C. (A) owner, Charles C. Blackmore Co., 1015 East Fifth Street, *Dayton, Ohio.*

BOWMAN, JOHN ALDEN (A) comptroller in charge of finances and general management, John W. Brown Mfg. Co., *Columbus, Ohio.*

BROOKE, HAROLD LEE (J) sales and service engineer, C. G. Spring Co., *Detroit*, (mail) 2736 Virginia Park.

BURKE, EDMUND L. (A) technical correspondent, Moto-Meter Co., 15 Wilbur Avenue, *Long Island City, N. Y.*

CARTER, H. A. (A) vice-president and sales manager, George R. Carter Co., *Connersville, Ind.*, (mail) 1818 Indiana Avenue.

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Representatives:
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Vosmer, W. F., general manager of sales.

DRUMM, EDGAR A. (A) principal, Y. M. C. A. Automobile School, 1736 G Street, Northwest, *City of Washington.*

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SCHWENZER, GEORGE A. (E S) student, University of Cincinnati, *Cincinnati*, (mail) 1985 Kinney Avenue.

SLATTERY, MICHAEL W. (A) instructor, Arsenal Technical Schools, *Indianapolis*, (mail) 2873 North Olney Street.

SMALL, FRED FULTON (M) mechanical superintendent, Pacific Electric Railway Co., 609 South Pacific Building, *San Francisco*.

SMARR, BENJAMIN M. (M) engineer, General Motors Corporation, *Detroit*.

STILGER, WILLIAM M. (A) parts manager, Hudson Motor Co. of Illinois, *Chicago*, (mail) 2558 Winnemac Avenue.

STOLL, ARNOLD E. (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1318 Forest Avenue.

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TYLER, DONALD WILSON (E S) student, University of Cincinnati, *Cincinnati*, (mail) 4606 Ward Street.

VINCENT, FIRST LIEUT. THOMAS K., (S M) Ordnance Department, Raritan Arsenal, *Metuchen, N. J.*

WHITE, HENRY J. (A) assistant experimental engineer, International Motor Co., New York City (mail) Highland Avenue, *Little Neck, N. Y.*

WILBURN, JOHN PAUL (A) sales engineer, Prest-O-Lite Co., Inc., *Indianapolis*, (mail) 3245 Central Avenue.

WILCOX, FRED A. (M) engineer, Advance-Rumely Co., *La Porte, Ind.*, (mail) 207 McCollum Street.

WILD, MARK (F M) works manager, Meteor works, Rover Co., Ltd., *Coventry, England*.

WILLIAMS, LEWIS F. (A) service sales manager, F. B. Smith Co., 36 Pyatt Street, *Youngstown, Ohio*.

WOOD, WALTER GRIFFITH (E S) student, University of Utah, *Salt Lake City, Utah*, (mail) 274-M Second Street, West.

WRIGHT, W. C. (A) manager of Main Line branch, John Warren Watson Co., Ardmore, Pa., (mail) *Radnor, Pa.*

YACKEY, GEORGE FREDERIC (E S) student, University of Illinois, Urbana, Ill., (mail) 4222 Flora Place, *St. Louis*.